QUESTION BANK

By Faculty of Architecture

COMPLETE 28 YEARS

Printed in colour for better recall in exam

4 BOOKS INSIDE

900+ pages A4 Better Contents

- QUESTION BANK 1
- QUESTION BANK 2
- QUESTION BANK 3
- GATE NUMERICALS

2018-1991

GATE ARCHITECTURE 2019

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PLEASE NOTE:

1. This is a preview. Only few pages are displayed. Total number of pages in this book (hard copy) is 902 pages.

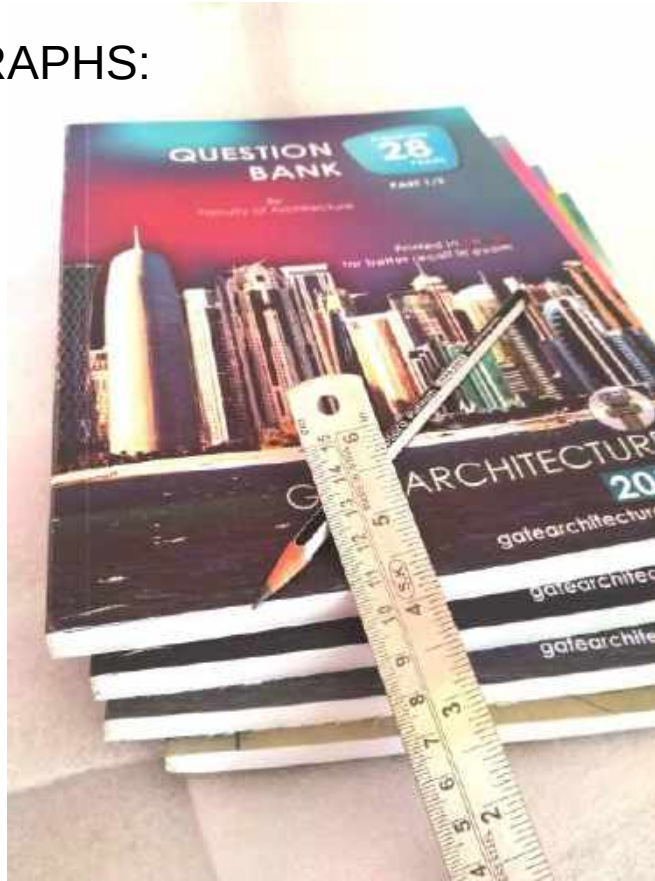
2. This book is divided into 4 booklets for ease of reading.
   (a) QUESTION BANK 1
   (b) QUESTION BANK 2
   (c) QUESTION BANK 3
   (d) GATE NUMERICALS

3. 702 pages are color printed. Research has found that color prints help to recall the contents effectively in exams in comparison to Black & White prints.

4. Contents of Topics, discussions, numericals etc. can be further included or excluded without prior information.

5. This the new edition for GATE 2019. All the shortcomings in the previous editions has been taken cared of.

ORIGINAL PHOTOGRAPHS:



Introduction

The best way to prepare for an exam like GATE is through comprehensive study of previous year question papers. It take less time to cover most part of the syllabus. Solving the previous year's GATE questions help aspirants to understand the exam pattern, knowing the level of questions and predict the pattern. At the same time you may be aware that just knowing the answers of previous year question paper is just not enough.

For example if the question is: The teahouse is a feature of which type of landscape architecture? And you learnt that the answer 'Japanese Garden'. It is best to support the answer with addition notes & figures about different types of gardens i.e. French, English, and Chinese etc. One reason for providing such notes is that it is rarely possible that in the next few years, the same question will be repeated. But it is quite possible that if a question is asked form related topic, you should answer it if you have gone through addition studies or notes.

Providing answer with essential notes & explanation is the main features of this Question Bank. It's been tried to cover the maximum part of the syllabus through providing supportive notes.

For further reading on particular topics, we have also provided QR codes & short links. Just scan or type the links to reach the web resources.

All illustrations are color printed. Paper published by National Center for Biotechnology Information, US suggests that there is positive effects of color illustration on cognitive process.

This question bank contains question papers of last 25 years from 1994 to 2018. All it makes it the complete question bank. When you go through all these, you will get an idea how question pattern and trend has changed over time. This will greatly help you to focus on the part of the syllabus which are frequently asked in exams.

This book should provide an edge to your study. Hopeful that it will make you confident and feel easy on question pattern. Best wishes for your preparation.

Quote"

"The interesting observation is to try to work with people but even more than that to try to make them successful. If you try to make others successful, they, in turn, will try to make you successful. No matter how brilliant you are, no matter how good you are, no matter how hard you work, if you rely only on yourself and believe you don't need the help of others, you are sadly mistaken. If you engage everybody around you by helping them, they will help you, in turn. And you will be more successful than you ever dreamed of." – Former director Goldman Sachs

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GATE SYLLABUS 2018 QUESTION PAPER 2018

Section 1: Architecture and Design Visual composition in 2D and 3D; Principles of Art and Architecture; Organization of space; Architectural Graphics; Computer Graphics– concepts of CAD, BIM, 3D modeling and Architectural rendition; Programming languages and automation. Anthropometrics; Planning and design considerations for different building types; Site planning; Circulation- horizontal and vertical; Barrier free design; Space Standards; Building Codes; National Building Code.

Elements, construction, architectural styles and examples of different periods of Indian and Western History of Architecture; Oriental, Vernacular and Traditional architecture; Architectural developments since Industrial Revolution; Influence of modern art on architecture; Art nouveau, Eclecticism, International styles, Post Modernism, Deconstruction in architecture; Recent trends in Contemporary Architecture; Works of renowned national and international architects.

Section 2: Building Materials, Construction and Management Behavioral characteristics and applications of different building materials viz. mud, timber, bamboo, brick, concrete, steel, glass, FRP, AAC, different polymers, composites.

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Section 6: Urban Planning and Housing Planning process; Types of plans - Master Plan, City Development Plan, Structure Plan, Zonal Plan, Action Area Plan, Town Planning Scheme, Regional Plan; Salient concepts, theories and principles of urban planning; Sustainable urban development; Emerging concepts of cities - Eco-City, Smart City, Transit Oriented Development (TOD), SEZ, SRZ etc.

Housing; Concepts, principles and examples of neighbourhood; Housing typologies; Slums; Affordable Housing; Housing for special areas and needs; Residential densities; Standards for housing and community facilities; National Housing Policies, Programs and Schemes.

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Urban Infrastructure – Transportation, Water Supply, Sewerage, Drainage, Solid Waste Management, Electricity and Communications.
Process and Principles of Transportation Planning and Traffic Engineering; Road capacity; Traffic survey methods; Traffic flow characteristics; Traffic analyses and design considerations; Travel demand forecasting; Land-use – transportation - urban form inter-relationships; Design of roads, intersections, grade separators and parking areas; Hierarchy of roads and level of service; Traffic and transport management and control in urban areas,; Mass transportation planning; Para-transits and other modes of transportation, Pedestrian and slow moving traffic planning; Intelligent Transportation Systems.
Principles of water supply and sanitation systems; water treatment; Water supply and distribution system; Water harvesting systems; Principles, Planning and Design of storm water drainage system; Sewage disposal methods; Methods of solid waste management - collection, transportation and disposal; Recycling and Reuse of solid waste; Power Supply and Communication Systems, network, design and guidelines. **General Aptitude**

Q.3 The compressive strength of M-25 concrete is
(A) 25 kg/sqm (B) 25 N/sqmm (C) 250 N/sqmm (D) 2.5 N/sqmm Answer (B)

IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation, the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm^2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively.
So, for M25, the M stands for mix and 25 represents the characteristic strength of concrete.
The **characteristic strength** is defined as the **strength** of the **concrete** below which not more than **5%** of the test results are expected to fall. In simpler terms, if you cast 100 cubes of 15cm*15cm*15cm and test their compressive strength using compression testing machines after 28 days, then not more than 5 cubes should fail at a value lesser than 25 N/mm^2 (25 MPa).

MPa = Mega Pascal (Mega = 10^6 & Pascal = N/m^2, So 1 MPa= 10^6 *N / m2)*
The pascal (symbol Pa) is the SI unit of pressure. It is equivalent to one newton per square metre. The unit is named after Blaise Pascal, the eminent French mathematician, physicist and philosopher.

Q.4 In Critical Path Method (CPM) for time scheduling, 'forward pass calculation' is carried out for determining
(A) Late start and early finish time (B) Early start and early finish time
(C) Late start and late finish time (D) Early start and late finish time Answer (B)

Q.5 Collapse of the World Trade Center (WTC), New York, in 2001, was due to
(A) Wind load failure
(B) Foundation failure
(C) Thermal performance failure of reinforcement steel in RCC
(D) Thermal performance failure of structural steel Answer (D)

About World Trade Center, New York: Minoru Yamasaki, the lead architect of the World Trade Center project proposed a plan that incorporated tall-standing twin towers; a design that would make these towers the tallest structures in the world at the time. Due to the height of the towers, more elevators than usual needed to be included, but this created a space problem on each floor. The concept of "sky lobbies" was introduced which were "floors where people could switch from a large-capacity express elevator to a local elevator that goes to each floor in a section." This saved a tremendous amount of space on each floor.
To make Yamasaki's design possible, the structural engineer developed a "tube" frame structural system. Such a system allowed for a more open floor plan at each level as the loads are distributed around the perimeter of the floor through the use of Vierendeel trusses.

The attack

After the 767 jet liner crashed into the world trade center building creating the worst terror attack in history, a fire burned for 56 minutes inside the World Trade Center building number two. The top 20 floors of the building collapsed on the 90 floors below. The entire one hundred and ten-story building collapsed in 8 seconds... After a fire burned inside WTC tower number one for 102 minutes, the top 30 floors collapsed on the lower 80 floors. And the entire one hundred and ten stories of this building collapsed in 10 seconds. You can say the reason they collapsed was they were struck with a 185 ton jet airliner and the 24,000 gallons of jet fuel caused a fire of 1500 to 2000 degrees F which weakened the steel and cause the collapse.

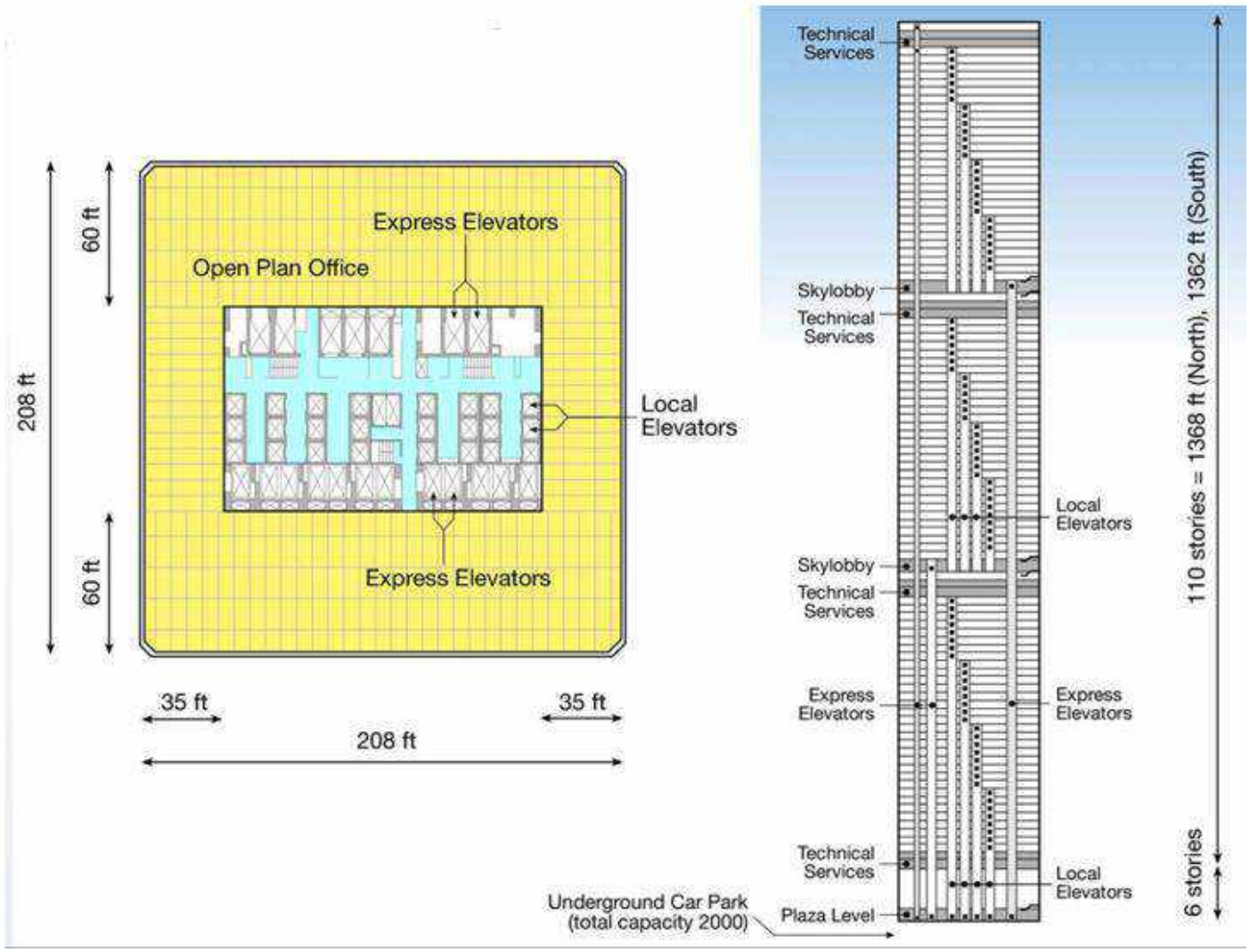

Figure: It is estimated over 200 people jumped to their death. It took about 10 seconds to hit the ground. What was the height from where the person jumped down? g = 9.8 m/sec^2

World Trade Center tower construction

In terms of structural system the twin towers departed completely from other high-rise buildings. Conventional skyscrapers since the 19th century have been built with a skeleton of interior supporting columns that supports the structure. Exterior walls of glass steel or synthetic material do not carry any load. The Twin towers are radically different in structural design as the exterior wall is used as the load-bearing wall. (A load bearing wall supports the weight of the floors.) The only interior columns are located in the core area, which contains the elevators. The outer wall carries the building vertical loads and provides the entire resistance to wind. The wall consists of closely spaced vertical columns (21 columns 10 feet apart) tied together by horizontal spandrel beams that girdle the tower at every floor. On the inside of the structure the floor sections consist of trusses spanning from the core to the outer wall.

Bearing walls and Open floor design

When the jet liners crashed into the towers based upon knowledge of the tower construction and high-rise firefighting experience the following happened: First the plane broke through the tubular steel-bearing wall. This started the building failure. Next the exploding, disintegrating, 185-ton jet plane slid across an open office floor area and severed many of the steel interior columns in the center core area. Plane parts also crashed through the plasterboard-enclosed stairways, cutting off the exits from the upper floors. The jet collapsed the ceilings and scraped most of the spray-on fire retarding asbestos from the steel trusses. The steel truss floor supports probably started to fail quickly from the flames and the center steel supporting columns severed by plane parts heated by the flames began to buckle, sag, warp and fail. Then the top part of the tower crashed down on the lower portion of the structure. This pancake collapse triggered the entire cascading collapse of the 110-story structure.

Steel Framing

The most noticeable change in the modern high-rise construction is a trend to using more steel and shaping lightweight steel into tubes, curves, and angles to increase its load bearing capability. The WTC has tubular steel bearing walls, fluted corrugated steel flooring and bent bar steel truss floor supports. To a modern high rise building designer steel framing is economical and concrete is a costly material. For a high-rise structural frame: columns, girders, floors and walls, steel provides greater strength per pound than concrete. Concrete is heavy. Concrete creates excessive weight in the structure of a building. Architects, designers , and builders all know if you remove concrete from a structure you have a building that weights less. So if you create a lighter building you can use columns, girders and beams of smaller dimensions, or better yet you can use the same size steel framing and build a taller structure. In News York City where space is limited you must build high. The trend over the past half-century is to create lightweight high buildings. To do this you use thin steel bent bar truss construction instead of solid steel beams. To do this you use hollow tube steel bearing walls, and curved sheet steel (corrugated) under floors. To do this you eliminate as much concrete from the structure as you can and replace it with steel. Lightweight construction means economy. It means building more with less. If you reduce the structure's mass you can build cheaper and builder higher. Unfortunately unprotected steel warps, melts, sags and collapses when heated to normal fire temperatures about 1100 to 1200 degrees F.

The fire service believes there is a direct relation of fire resistance to mass of structure. The more mass the more fire resistance. The best fire resistive building in America is a concrete structure. The structures that limit and confine fires best, and suffer fewer collapses are reinforced concrete pre WWII buildings such as housing projects and older high rise buildings like the empire state building, The more concrete, the more fire resistance; and the more concrete the less probability of total collapse. The evolution of high- rise construction can be seen, by comparing the empire state building to the WTC. My estimate is the ratio of concrete to steel in the empire state building is 60/40. The ratio of concrete to steel in the WTC is 40/60. The tallest building in the world, the Petronas Towers, in Kula Lumpur, Malaysia, is more like the concrete to steel ratio of the empire state building than concrete to steel ratio of the WTC. Donald Trump in New York City has constructed the tallest reinforced concrete high-rise residence building.

Figure: The Windows on the World dining room, on the 107th floor of the North Tower of WTC. (Photo: Ezra Stoller/Esto). Between the glass window, steel columns are there.

Effects of jet crash and fire on a skeleton steel high rise

A plane that only weighted 10 tons struck the Empire State Building and the high-octane gasoline fire quickly flamed out after 35 minutes. When the firefighters walked up to the 79 floor most of the fire had dissipated. The Empire State Building in my opinion, and most fire chiefs in New York City, is the most fire safe building in America. I believe it would have not collapsed like the WTC towers. I believe the Empire State Building, and for that matter any other skeleton steel building in New York City, would have withstood the impact and fire of the terrorist's jet plane better than the WTC towers. If the jet liners struck any other skeleton steel high rise, the people on the upper floors and where the jet crashed may not have survived; there might have been local floor and exterior wall collapse. However, I believe a skeleton steel frame high rise would not suffer a cascading total pancake collapse of the lower floors in 8 and 10 seconds. Hopefully some engineer using computer calculations, can reconstruct the effects of a 767 jetliner crashing into another New York City high building. In any other high rise in New York City, I say, the floors below the crash and fire, would not collapse in such a total a cascading pancake cave-in. Most of the occupants and rescuers killed in the WTC tower collapse were on the lower floors.

Source: http://vincentdunn.com/wtc.html

Q.6 During the construction of tall buildings, the equipment used for hoisting building materials to the upper floors is a

(A) Goods lift (B) Capsule lift
(C) Gantry crane (D) Tower crane Answer (D)

Q.7 A Rock-cut style of architecture is represented by

(A) Shyama Rama Temple, Bishnupur (B) Kailasa Temple, Ellora
(C) Kandariya Mahadeva Temple, Khajuraho (D) Sanchi Stupa, Sanchi Answer (B)

About **Bishnupur** (The temple town, West-Bengal): Known for its beautiful terracotta temples, Bishnupur flourished as the capital of the Malla kings from the 16th to the early 19th centuries. The architecture of these intriguing temples is a bold mix of Bengali, Islamic and Oriya (Odishan) styles. Intricately detailed facades of numerous temples play out scenes of the Hindu epics, the Ramayana and Mahabharata.

Stone has always been in short supply in the vast flood plains of Bengal. Hence the architects had to restore to other substitute. As clay was easily available the burnt clay bricks soon became a good substitute of stone. This gave rise to a new form of temple architecture and lead to the construction of elaborately decorated terracotta temples.

Terracotta literally means baked earth in Italian but West Bengal has the distinction of housing some of the finest terracotta art in the world. The terracotta art reached its pinnacle under the patronage of the Malla Kings of Bishnupur during the seventeenth century.

Temples in Bishnupur: There are more than 20 temples in a small vicinity. Few described below.

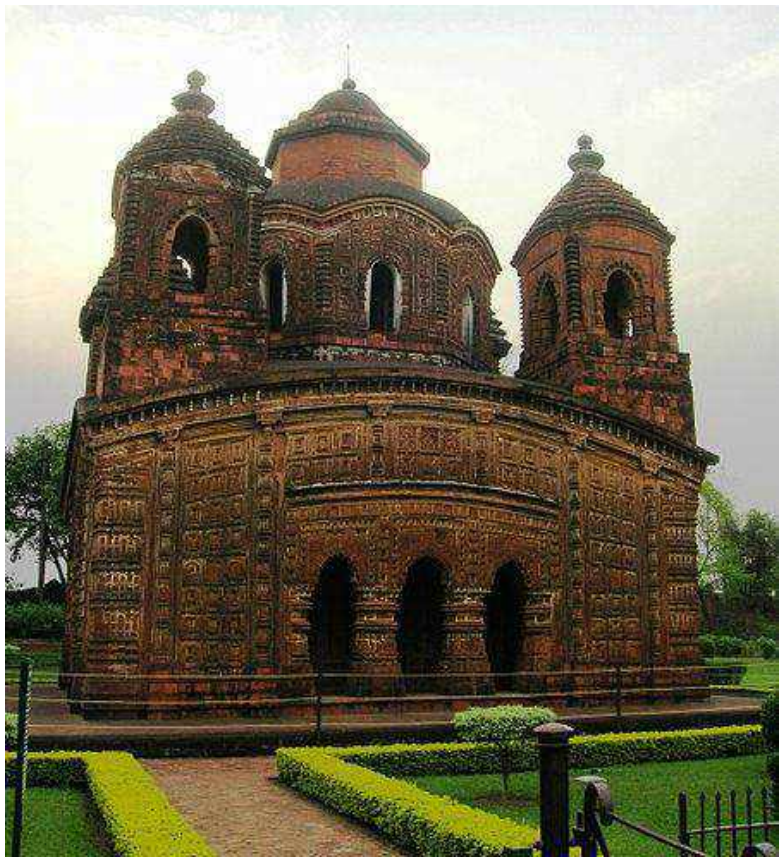

Figure: Shyamrai Temple, Bishnupur (Pancha Ratna Temple)

Shyamrai Temple: A left turn from the Ghumghar leads to the Shyamrai Temple**,** popularly known as the Pachchura temple, because of its five pinnacles. Built by Mallaraja Raghunath Singha in 1643 this is terracotta at its best.

Approached by triple arched entrance on all the four sides the Shyamrai Temple contains terracotta on all its four sides including the inner walls and the pinnacles. The Ras Chakra and love making scenes of Radha – Krishna are the most sort after terracotta panels of the Shyamrai Temple.

Figure: Ras Mancha, Bishnupur

"The Kailasa Temple, it is safe to say, is one of the most astonishing 'buildings' in the history of architecture. This shrine was not constructed of stone on stone, it was in fact not constructed at all: it was carved, sculpted from the volcanic hillside! A squared, U-shaped trench was first cut into the slope to a depth of close to 100 feet. The 'liberated' mass in the center was then patiently carved from the living rock to produce a freestanding, two-story temple of dazzling complexity. The temple, which is dedicated to Shiva, measures 109 feet wide by 164 feet long. It stands on an elevated plinth to attain greater presence in its tight surroundings. The complex consists of entry, Nandi (i.e. bull) shrine, open porch, main hall, and inner sanctum. Variously scaled panels, friezes, and sculpture highlight many surfaces."

Source: http://www.greatbuildings.com/buildings/kailasa_temple.html
https://postcard.news/why-kailash-temple-is-not-considered-as-a-wonder-of-the-world-forget-constructing-this-temple-again-it-cant-even-be-destroyed/
http://www.themysteriousindia.net/mind-boggling-images-of-the-kailasa-temple/

Figure: Arial view of Kailasa Temple

YouTube

Watch on YouTube "**Kailasa Temple in Ellora Caves - Built with Alien Technology?**"

http://bit.ly/KailasaTempleMade

GATE SYLLABUS [Contents covered in this section are highlighted and question no. in superscript] QUESTION PAPER 2016

Section 1: Architecture and Design Visual composition in 2D and 3D; Principles of Art and Architecture[8]; Organization of space; Architectural Graphics[11]; Computer Graphics– concepts of CAD, BIM, 3D modeling and Architectural rendition; Programming languages and automation. Anthropometrics; Planning and design considerations for different building types; Site planning; Circulation- horizontal and vertical; Barrier free design; Space Standards[16]; Building Codes; National Building Code[7].

Elements, construction, architectural styles and examples of different periods of Indian and Western History of Architecture[15,16,26]; Oriental, Vernacular and Traditional architecture[1,29]; Architectural developments since Industrial Revolution; Influence of modern art on architecture; Art nouveau, Eclecticism, International styles, Post Modernism, Deconstruction in architecture; Recent trends in Contemporary Architecture[2,34]; Works of renowned national and international architects[13,21,32,36,37].

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Housing[45]; Concepts, principles and examples of neighbourhood; Housing typologies[51]; Slums[12]; Affordable Housing; Housing for special areas and needs; Residential densities[24]; Standards for housing and community facilities; National Housing Policies, Programs and Schemes[3].

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Urban Infrastructure – Transportation, Water Supply, Sewerage, Drainage[53], Solid Waste Management[9], Electricity and Communications.

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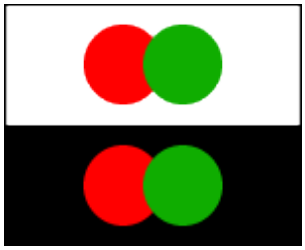
Inside and out the Vitra fire station is a series of complex spatial arrangements that evoke a sense of illusive instability while still retaining some semblance of stability and structure. Yet all the while exhibiting simple, clean lines that converge together to create a compositional complexity throughout the station.
Today, the fire house has been converted into a museum that showcases Vitra's chair designs after the fire district lines had been redrawn. Answer : A

25. A combination of colours forming an equilateral triangle in a Colour Wheel is called

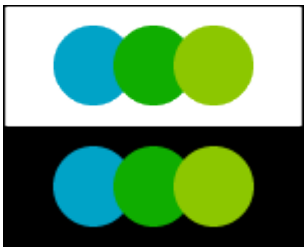
(A) Analogous Scheme (B) Triad Scheme
(C) Split Complementary Scheme (D)Double Complementary Scheme

Notes: Below are shown the basic color chords based on the **color wheel**.

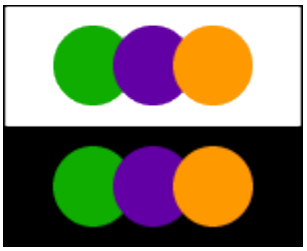
Complementary
Colors that are opposite each other on the color wheel are considered to be complementary colors (example: red and green).
The high contrast of complementary colors creates a vibrant look especially when used at full saturation. This color scheme must be managed well so it is not jarring.
Complementary colors are tricky to use in large doses, but work well when you want something to stand out.
Complementary colors are really bad for text.



Analogous
Analogous color schemes use colors that are next to each other on the color wheel. They usually match well and create serene and comfortable designs.
Analogous color schemes are often found in nature and are harmonious and pleasing to the eye.
Make sure you have enough contrast when choosing an analogous color scheme.
Choose one color to dominate, a second to support. The third color is used (along with black, white or gray) as an accent.



Triad
A triadic color scheme uses colors that are evenly spaced around the color wheel.
Triadic color harmonies tend to be quite vibrant, even if you use pale or unsaturated versions of your hues.
To use a triadic harmony successfully, the colors should be carefully balanced - let one color dominate and use the two others for accent.

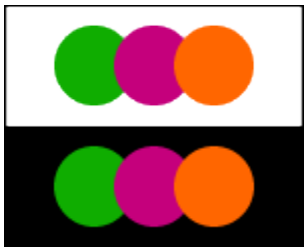


Split-Complementary

The split-complementary color scheme is a variation of the complementary color scheme. In addition to the base color, it uses the two colors adjacent to its complement.

This color scheme has the same strong visual contrast as the complementary color scheme, but has less tension.

The split-complimentary color scheme is often a good choice for beginners, because it is difficult to mess up.



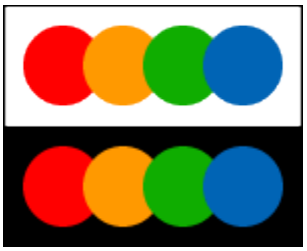
Rectangle (tetradic)

The rectangle or tetradic color scheme uses four colors arranged into two complementary pairs.

This rich color scheme offers plenty of possibilities for variation.

The tetradic color scheme works best if you let one color be dominant.

You should also pay attention to the balance between warm and cool colors in your design.

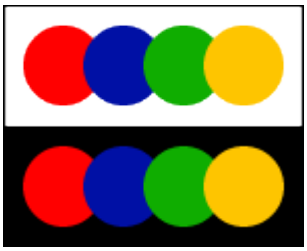


Square

The square color scheme is similar to the rectangle, but with all four colors spaced evenly around the color circle.

The square color scheme works best if you let one color be dominant.

You should also pay attention to the balance between warm and cool colors in your design.



Answer : B

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26. Desire Line diagram helps in

(A) completion of a project by a desired date
(B) meeting demand and supply in desired category of housing
(C) determining income versus expenditure pattern of individuals
(D) Origin-Destination analysis in transport planning

Notes: **Definition**: Origin-destination (O-D) surveys provide a detailed picture of the trip patterns and travel choices of a city's or region's residents.

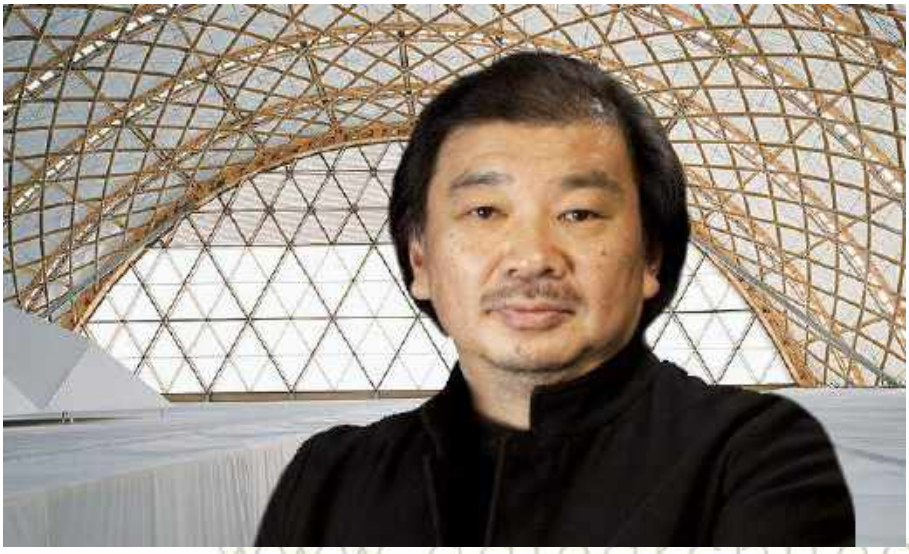
These surveys collect valuable data related to households, individuals and trips. This information allows stakeholders to understand :

>Travel patterns and characteristics
>Measure trends
>Provide input to travel demand model development
>Forecasting, and planning for area-wide transportation needs and services
>Progress in implementing transportation policies.

'Hoju-ryo' (1994) and Municipal Museum (1991), both in Yatsushiro, were his first major institutional buildings. They launched a decade of success, including the Nagayama Amusement Complex in Tokyo (1993) and the almost completely transparent ITM Building in Matsuyama (1993), leading to his masterpiece, completed in 2001 – the Sendai Médiathèque.

Seldom has a building been so eagerly awaited. Widely trailed in the architectural press before, during and after construction, the média¬thèque was conceived as a seven-storey structure, clad in glass and held up by branch-like steel members arranged in thirteen tubular columns housing services and allowing light to penetrate the depth of the floor plate. It is spectacular, at once referring to the characteristic trees that line the roads of Sendai and providing a 22,000-square-metre space of incredible lightness. The médiathèque derives its diagram from Le Corbusier's 1914 Dom-lno project, but also, again, refers to the movable screens and walls of the traditional Japanese house. The fit-out, with furniture and screens designed by Ross Lovegrove dividing the interior, has been criticized by some as being unsympathetic to Ito's structure, but it remains one of the most important buildings of recent years in Japan, and confirms Ito's place as the pre¬eminent voice in contemporary Japanese architecture.

Shigeru Ban: Citing his innovative approach to structure and material as well as his commitment to compassionate design, the Pritzker Jury has selected Japanese architect Shigeru Ban as the 2014 winner of the Pritzker Prize. Ban is the thirty-eighth recipient of the Pritzker Prize and its seventh Japanese recipient.



Japan Pavilion EXPO 2000 HANNOVER – Germany, 2000

Despite construction problems, the abrupt replacement of the engineer, months long construction delays, and the necessary addition of a PVC membrane over the paper membrane for fire safety issues, the Pavilions has been a great leap forward in the field of paper architecture. The main theme of the Hanover Expo was the environment and the basic concept behind the Japan Pavilion was to create a structure that would produce as little industrial waste as possible when it was dismantled. The goal was either to recycle or reuse almost all of the materials that went into the building. The first structural idea was for a tunnel arch of paper tubes, similar to the Paper Dome. However, the Paper Dome was limited by the high cost of wooden joints. I proposed a grid shell using lengthy paper tubing and without joints to my collaborator, Frei Otto. The tunnel arch would be about 73.8m long, 25m wide, and 15.9m high. The most critical factor was lateral strain along the long side, so instead of a simple arch I chose a grid shell of three-dimensional curved lines with indentations in the height and width directions, which are stronger when it comes to lateral strain.

Q.5 Hip roof is formed by surfaces sloping in

(A) One direction
(B) Two directions
(C) Three directions
(D) Four directions

Answer (D)

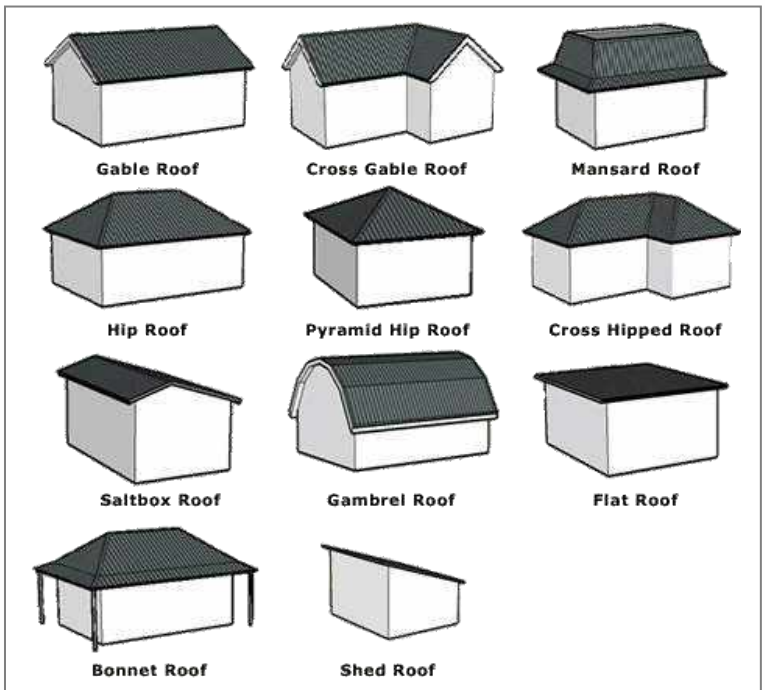


Figure: Types of roofs

Figure: **Bonnet Roof**. This type of room is similar to the pyramid roof or hip roof. The difference, as seen here , is that two of the slides slope out an angle. The most common purpose for this is to cover a veranda or outdoor porch area.

Figure: **Gambrel.** This type of roof is very similar to the Mansard Roof. The core differences are that the gambrel has vertical gable ends and the roof hangs over the facade of the home whereas the Mandrel Roof does not. Additionally this one is Dutch-inspired instead of French.

Figure: **Hip Roof.** This roof is very similar to the pyramid roof. The difference is that instead of coming to a point at the top the four sides meet at a ridge or a flat spot like we see here. This is architecturally more practical.

Figure: **Arched Roof.** The arched roof is typically only used on a portion of the home (as seen here) but definitely adds a great aesthetic touch the architecture of the house

Figure: **Cross Gabled Roof**. There are many types of gabled roofs (roofs that essentially look like triangles from the front of the home). I enjoy the cross gabled roof which is used in homes with extra wings so that each portion of the home has its own triangular gabled roof as seen in this photo.

Figure: **Pyramid Roof.** As the name suggests, this is a type of roof that is shaped like a pyramid. We see it here on two different portions of this extravagant home. This type of roof is usually used either on small portions, like this, or on small structures such as a garage or pool house.

- maintaining a dense hedge
- maintaining a desired tree form or special garden forms

Prune to improve plant appearance

Appearance in the landscape is essential to a plant's usefulness. For most landscapes, a plant's natural form is best. Avoid shearing shrubs into tight geometrical forms that can adversely affect flowering. Alter a plant's natural form only if it needs to be confined or trained for a specific purpose. When plants are pruned well, it is difficult to see that they have been pruned! Prune to:

- control plant size
- keep evergreens well-proportioned
- remove unwanted branches, waterspouts, suckers, and undesirable fruiting structures that detract from plant appearance

Prune to protect people and property

- Remove dead branches
- Have hazardous trees taken down
- Prune out weak or narrow-angled tree branches that overhang homes, parking areas, and sidewalks – anyplace falling limbs could injure people or damage property
- Eliminate branches Eliminate branches that interfere with street lights, traffic signals, and overhead wires. REMEMBER, DO NOT attempt to prune near electrical and utility wires. Contact utility companies or city maintenance workers to handle it
- Prune branches that obscure vision at intersections
- For security purposes, prune shrubs or tree branches that obscure the entry to your home

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Topiary is the horticultural practice of training live perennial plants by clipping the foliage and twigs of trees, shrubs and subshrubs to develop and maintain clearly defined shapes, perhaps geometric or fanciful. The term also refers to plants which have been shaped in this way. As an art form it is a type of living sculpture. The word derives from the Latin word for an ornamental landscape gardener, *topiarius*, a creator of *topia* or "places", a Greek word that Romans also applied to fictive indoor landscapes executed in fresco.

Figure: **Topiary** , a horticultural practice.

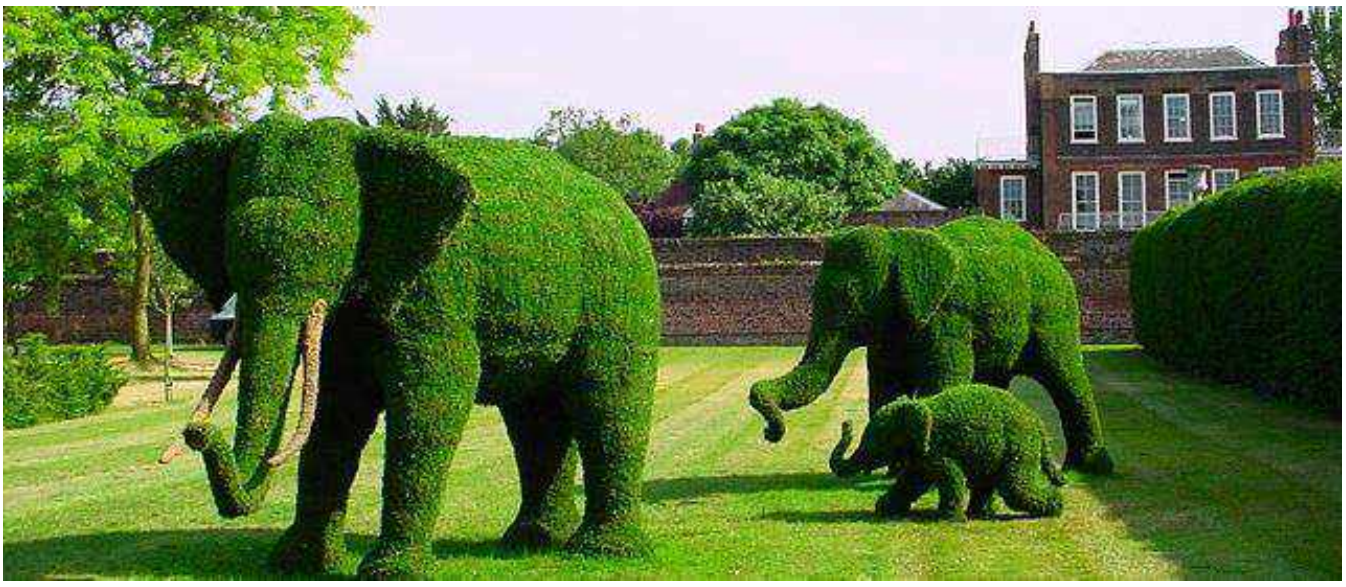
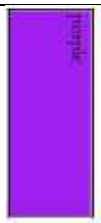
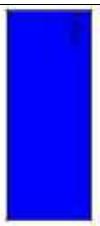


Figure: **With Topiary technique**, complex shape can be achieved.

							
Residential	Shopping, business	Industrial, manufacturing, and waste-related activities	Social, institutional, or infrastructure-related activities	Travel or movement	Leisure activities	Natural resources	No human activity or unclassifiable activity

(A) P-1, Q-3, R-2, S-5 (B) P-2, Q-1, R-3, S-4(C) P-3, Q-4, R-5, S-2 (D) P-3, Q-1, R-2, S-4

Answer (D)

Q.33 Match the books in Group I with their corresponding authors in Group II

Group I	Group II
P. Design of Cities	1. Amos Rapoport
Q. On the Cultural Origin of Settlements	2. Leo Jacobson and Ved Prakash
R. Urbanization and National Development	3. Edmond Bacon
S. Planning Theory	4. Christopher Alexander
	5. Andreas Faludi

(A) P-3, Q-4, R-1, S-5 (B) P-3, Q-1, R-2, S-5 (C) P-4, Q-3, R-5, S-2 (D) P-3, Q-4, R-1, S-2 Answer (B)

Q.34 Match the temples in Group I with their corresponding historical periods in Group II

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Group I	Group II
P. Vaikuntha Perumal Temple	1. Vijaynagara
Q. Meenakshi Temple	2. Chalukya
R. Durga Temple	3. Chola
S. Brihadeshwara Temple	4. Pandya
	5. Pallava

(A) P-2, Q-3, R-5, S-1 (B) P-5, Q-1, R-4, S-3 (C) P-3, Q-5, R-2, S-1 (D) P-5, Q-4, R-2, S-3

Durga Temple, Aihole

Figure: Durga Temple, Aihole

The Durga temple is an example of southern (Dravidian) architectural type, with a later northern type superstructure imposed upon it-an incongruity apparent from the fact that the superstructure is a square structure clumsily fitted over an apsidal cella. The temple stands on a high moulded upapitha (sub-base), apsidal on plan and carrying a peripheral row of columns on its edge that surround the moulded adhishthana and walls of an apsidal vimana and its front mandapa. Thus the colonnade forms a covered circumambulatory with a sloping roof. The open mandapa is continued forward on a base of smaller width. The peripheral pillars of the front mandapa and those at the forward end of the circumambulatory have large statuary on them. The adhishthana inside is again apsidal, moulded with all the components, and carries the apsidal wall enclosing the inner apsidal wall of the cella or garbha-griha and a closed maha-mandapa in front of it, with two linear rows of four columns in each row that divide it into a central nave and lateral aisles.

GATE SYLLABUS [Contents covered in this section are highlighted and question no. in superscript] QUESTION PAPER 2012

Section 1: Architecture and Design Visual composition in 2D and 3D; Principles of Art and Architecture; Organization of space; Architectural Graphics[2]; Computer Graphics– concepts of CAD[40], BIM, 3D modeling and Architectural rendition; Programming languages and automation. Anthropometrics; Planning and design considerations for different building types; Site planning[8,15]; Circulation- horizontal and vertical; Barrier free design; Space Standards; Building Codes; National Building Code.

Elements, construction[1], architectural styles and examples of different periods of Indian[36] and Western History of Architecture; Oriental, Vernacular and Traditional architecture[43,46]; Architectural developments since Industrial Revolution; Influence of modern art on architecture; Art nouveau, Eclecticism, International styles, Post Modernism[7], Deconstruction in architecture; Recent trends in Contemporary Architecture; Works of renowned national and international architects[32,39,42].

Section 2: Building Materials, Construction and Management Behavioral characteristics and applications of different building materials[9,14] viz. mud, timber, bamboo, brick, concrete, steel, glass[22], FRP, AAC, different polymers, composites.

Building construction techniques[6,50,51], methods[17] and details[45]; Building systems and prefabrication of building elements; Principles of Modular Coordination; Estimation, specification, valuation[30], professional practice; Construction planning and equipments; Project management techniques[24] e.g. PERT, CPM etc.

Section 3: Building and Structures Principles of strength of materials; Design of structural elements in wood, steel and RCC[20]; Elastic and Limit State design; Structural systems in RCC[25,28] and Steel[31]; Form and Structure; Principles of Pre-stressing; High Rise and Long Span structures, gravity and lateral load resisting systems; Principles and design of disaster resistant structures[10].

Section 4: Environmental Planning and Design Ecosystem- natural and man-made ecosystem; Ecological principles; Concepts of Environmental Impact Analysis; Environmental considerations in planning and design; Thermal comfort[47], ventilation[29] and air movement; Principles of lighting and illumination[26,38]; Climate responsive design; Solar architecture[54,55]; Principles of architectural acoustics; Green Building- Concepts and Rating; ECBC[4]; Building Performance Simulation and Evaluation; Environmental pollution[37]- types, causes, controls and abatement strategies.

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Section 6: Urban Planning and Housing Planning process; Types of plans[35] - Master Plan, City Development Plan, Structure Plan, Zonal Plan, Action Area Plan, Town Planning Scheme, Regional Plan; Salient concepts, theories and principles of urban planning; Sustainable urban development; Emerging concepts of cities - Eco-City, Smart City, Transit Oriented Development (TOD), SEZ, SRZ etc.

Housing; Concepts, principles and examples of neighbourhood; Housing typologies; Slums; Affordable Housing; Housing for special areas and needs; Residential densities; Standards for housing and community facilities[27]; National Housing Policies, Programs and Schemes[33].

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Urban Economics; Law of demand and supply of land and its use in planning; Social, Economical and environmental cost benefit analysis; Techniques of financial appraisal; Management of Infrastructure Projects; Development guidelines such as URDPFI; Planning Legislation and implementation – Land Acquisition Act, PPP etc.; Local self-governance.

Section 8: Services, Infrastructure and Transportation Building Services: Water supply[44]; Sewerage[16] and drainage systems; Sanitary fittings and fixtures; Plumbing systems; Principles of internal and external drainage system; Principles of electrification of buildings; Intelligent Buildings; Elevators and Escalators - standards and uses; Air-Conditioning systems; Firefighting Systems; Building Safety and Security systems. Urban Infrastructure – Transportation, Water Supply, Sewerage, Drainage, Solid Waste Management, Electricity and Communications.

Process and Principles of Transportation Planning and Traffic Engineering; Road capacity; Traffic survey methods; Traffic flow characteristics; Traffic analyses and design considerations; Travel demand forecasting; Land-use – transportation - urban form inter-relationships; Design of roads[3], intersections[41], grade separators and parking areas; Hierarchy of roads and level of service; Traffic and transport management and control in urban areas,; Mass transportation planning[12]; Para-transits and other modes of transportation, Pedestrian and slow moving traffic planning; Intelligent Transportation Systems. Principles of water supply and sanitation systems; water treatment; Water supply and distribution system; Water harvesting systems; Principles, Planning and Design of storm water drainage system; Sewage disposal methods; Methods of solid waste management - collection, transportation and disposal; Recycling and Reuse of solid waste; Power Supply and Communication Systems, network, design and guidelines. General Aptitude [56 to 65]

Population Pyramid
A population pyramid illustrates the age and sex structure of a country's population and may provide insights about political and social stability, as well as economic development. The population is distributed along the horizontal axis, with males shown on the left and females on the right. The male and female populations are broken down into 5-year age groups represented as horizontal bars along the vertical axis, with the youngest age groups at the bottom and the oldest at the top. The shape of the population pyramid gradually evolves over time based on fertility, mortality, and international migration trends.

Q.6 'Cover block' is used as a building construction component in
(A) Brick wall
(B) Curtain wall
(C) Steel truss
(D) RC beam

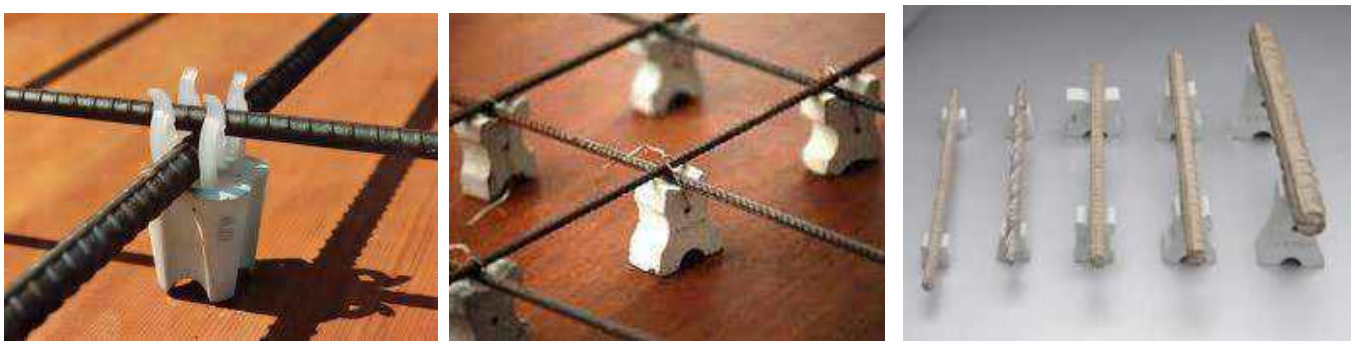

Figure: A **Cover Block** is essentially a spacer that is used to lift the rebar matrix off the ground so that concrete may flow underneath the rebar.

Answer (D)

Q.7 'Villa Savoye', Paris is an example of
(A) Modernism
(B) Post Modernism
(C) Deconstructivism
(D) Eclecticism

Figure: **Villa Savoye**

The Villa Savoye is probably Corbusier's best known building from the 1950s, it had enormous influence on international modernism. It was designed addressing his emblematic "Five Points", the basic tenets in his new architectural aesthetic:

1. Support of ground-level pilotis, elevating the building from the earth and allowed an extended continuity of the garden beneath.
2. Functional roof, serving as a garden and terrace, reclaiming for nature the land occupied by the building.
3. Free floor plan, relieved of load-bearing walls, allowing walls to be placed freely and only where aesthetically needed.
4. Long horizontal windows, providing illumination and ventilation.
5. Freely-designed facades, serving only as a skin of the wall and windows and unconstrained by load-bearing considerations.

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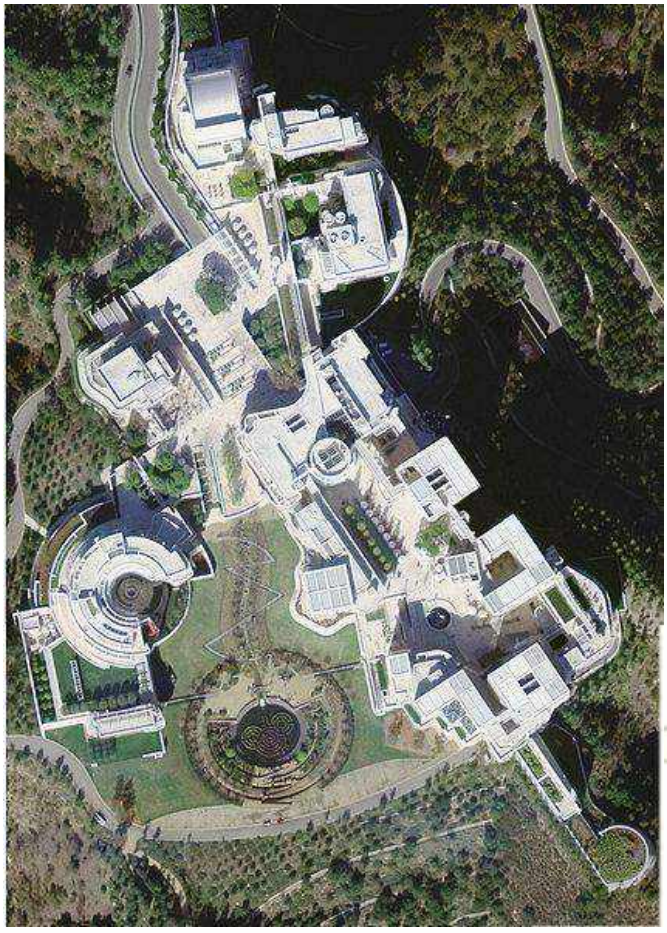
inspired by the wings of a bird; a cabled pedestrian bridge with a soaring mast inspired by the form os a sailboat and a curving single-storey galleria reminiscent of a wave. "Rather than just add something to the existing buildings, I also wanted to add something to the lakefront. I have therefore worked to infuse the building with a certain sensitivity to the culture of the lake - the boats, the sails and the always changing landscape".

Getty Center, Los Angeles



The Getty Center, in Los Angeles, California, is a campus of the Getty Museum. It is well known for its architecture, gardens, and views overlooking Los Angeles. The Center branch of the Museum features pre-20th-century European paintings, drawings, illuminated manuscripts, sculpture, and decorative arts; and 19th- and 20th-century American, Asian, and European photographs. In addition, the Museum's collection at the Center includes outdoor

sculpture displayed on terraces and in gardens and the large Central Garden designed by Robert Irwin. Among the artworks on display is the Vincent Van Gogh painting Irises. Designed by **architect Richard Meier**, the campus also houses the Getty Research Institute (GRI), the Getty Conservation Institute, the Getty Foundation, and the J. Paul Getty Trust. The Center's design included special provisions to address concerns regarding earthquakes and fires.

Freedom Tower, New York

One World Trade Center (also known as the Freedom Tower, 1 World Trade Center and 1 WTC) is the main building of the rebuilt World Trade Center complex in New York City. The supertall structure has the same name as the North Tower of the original World Trade Center, which was completely destroyed in the terrorist attacks of September 11, 2001.

Many of Daniel Libeskind's original concepts from the 2002 competition were discarded from the tower's final design. One World Trade Center's final design consisted of simple symmetries and a more traditional profile, intended to compare with selected elements of the contemporary New York skyline. The tower's central spire draws from previous buildings, such as the Empire

Freedom Tower, New York

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Urban Infrastructure – Transportation, Water Supply, Sewerage, Drainage, Solid Waste Management, Electricity and Communications.

Process and Principles of Transportation Planning and Traffic Engineering; Road capacity; Traffic survey methods; Traffic flow characteristics; Traffic analyses and design considerations; Travel demand forecasting; Land-use – transportation - urban form inter-relationships; Design of roads, intersections, grade separators and parking areas[9]; Hierarchy of roads and level of service; Traffic and transport management and control in urban areas,; Mass transportation planning; Para-transits and other modes of transportation, Pedestrian and slow moving traffic planning; Intelligent Transportation Systems. Principles of water supply and sanitation systems; water treatment; Water supply and distribution system; Water harvesting systems; Principles, Planning and Design of storm water drainage system; Sewage disposal methods; Methods of solid waste management - collection, transportation and disposal; Recycling and Reuse of solid waste; Power Supply and Communication Systems[21], network, design and guidelines. General Aptitude [56 to 65]

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Q. 1 — Q. 25 carry one mark each.

Q1. Capital town of Gandhinagar has been designed by
(A) Norman Foster
(B) B.V. Doshi
(C) H.K. Mewada
(D) Le Corbusier

Notes: The planning of Gandhinagar was done by two Indian Town Planners; Prakash M Apte & H. K. Mewada, who had apprenticed with Le Corbusier in Chandigarh planning.
Bhubaneswar was planned by the German Otto Koenigsberger.
Buildings by **Norman Foster:**

Expo MRT Station Singapore:

Figure: Expo MRT Station Singapore

This is a structure built in the "space age" architecture style, with its innovative columns and pillars free design allowing for a sense of open space, not hindered by concrete walls. All the pillars actually support the structure by being hidden behind the train tracks and away from the circulated spaces. Thus, an immense free space has been created in order to facilitate mass circulation of people on a daily basis.
The main construction materials included glass, steel and titanium. It was opened to public in January 2001, and it is built with full access for people with disabilities as well.

Hearst Tower, New York City
The Hearst tower can be found on the top of the 1928 constructed office building. The tower only has 46 floors, and is 182 meters high. It was constructed between 2003 and 2006, and it is considered one very important environmentally friendly or "green" building in the world (it was actually the first such structure in New York).
The design allowed for using much less steel frame than normally such a building would require (with about 25% less), thanks to its "diagrid-weaved" pattern. Other environmentally friendly patterns include the limestone heat conductive floors of the atrium, and the huge rainwater collector tank, which allows for water reutilisation inside the building (for watering purpose and for the cooling system mainly). It is also the very first building in New York to receive the Gold LEED (Leadership in Energy and Environmental Design) Certification.

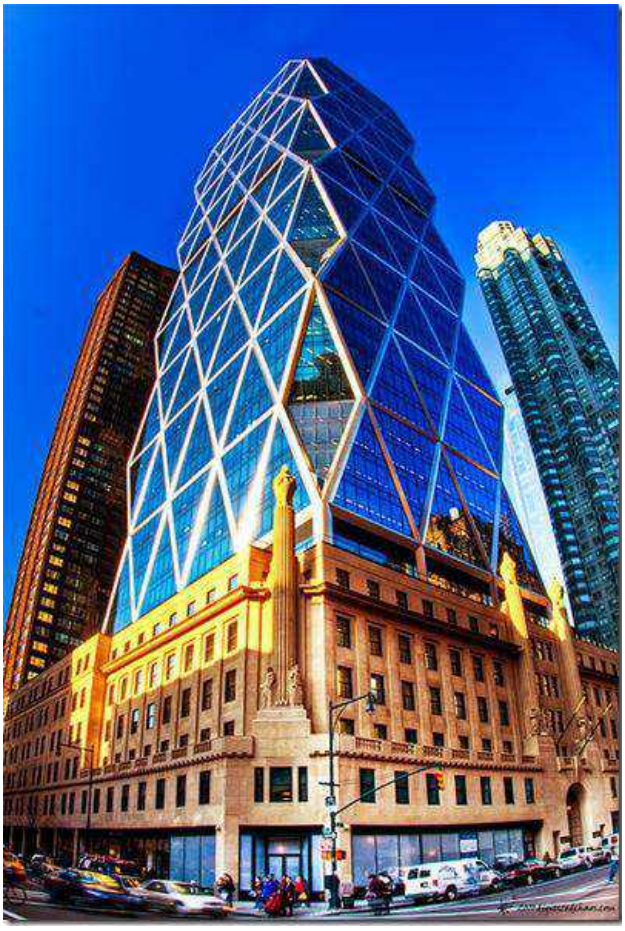

Figure: Hearst Tower, New York City

Reichstag, New German Parliament

A landmark for the German people, the Reichstag went through a restoration session in 1993. Based on the plans of Norman Foster, the dome was rebuilt in the form of a glass cupola, with a spiral walkway represented through a conical

structure. It stands as the most prominent landmarks of Berlin today, receiving millions of visitors from all around the world.

The conical structure within the interior uses mirrored facades to reflect the sunlight and spread it within the building. Moreover, this is an environmentally friendly building, being highly energy efficient.

Figure: Reichstag, New German Parliament

City Hall, London

This modern architectural style, slightly tilted structure has been opened to public in 2002, and it was built following the master plans of Norman Foster and associates. Its overall cost for construction was £65 million, and it is a highly energy efficient building. It has a bulbous shape, which serves to reduce the actual surface area, thus allowing energy saving.

Figure: City Hall, London

The design of the building heavily borrows from the design of the Reichstag Dome in Berlin, with its helical stairway structure and the oval/rounded shape of the building. Also, thanks to the materials used and the overall design, the building is a symbol for "transparency", just like Reichstag is.

Figure: Torre Caja Madrid, Spain

Torre Caja Madrid, Spain

This is a skyscraper with 250 meters in height, and it easily earns its place on the Top 200 Tallest Buildings in the World. It was completed in 2009, and it took 6 years to complete. Currently, the building serves as the main office space for the largest banking institution in Spain (Caja Madrid). It is a highly modern structure not only on the outside, but offering great flexibility and large comfortable office spaces and conference rooms inside.

Clyde Auditorium Glasgow

This beautiful, contemporary style building is a very popular concert venue of Glasgow Scotland, also known as "The Armadillo" (because of its resemblance to the armadillo mammal). It has been opened to public in 1997, and it has 30,000 seats. The shape of the building was not only chosen for pure design, but it also has a very practical side: to get the best acoustic experience.

2K. Note that Kelvin is used as the scale of temperature difference, but this is numerically equal to
oC. So for example, one square meter of a standard single glazed window will transmit about 5.6 watts of energy for each degree difference either side of the window or a U - Value
of 5.6. A double glazed window will be significantly better with a U-value of 2.8 i.e. only transmitting 2.8 watts of energy in similar conditions.

What is a U value?

A U value is a measure of heat loss in a building element such as a wall, floor or roof. It can also be referred to as an 'overall heat transfer co-efficient' and measures how well parts of a building transfer heat. This means that the higher the U value the worse the thermal performance of the building envelope. A low U value usually indicates high levels of insulation. They are useful as it is a way of predicting the composite behaviour of an entire building element rather than relying on the properties of individual materials.

Why use U values?

U values are important because they form the basis of any energy or carbon reduction standard. In practice, nearly every external building element has to comply with thermal standards that are expressed as a maximum U value. Knowledge of how to simply calculate U values at an early stage in the design process, avoids expensive re-working later on in a project. It allows the designer to test the feasibility of their project at an early stage to ensure it is fit for purpose and will comply with regulatory frameworks.

When to use U-values

U values are calculated at stages D onwards in the design process. A critical milestone in any building project is obtaining building regulation approval. For this a SAP calculation for housing or an SBEM procedure for non domestic work is obligatory. As part of this process, the build up of any external construction element must be specified and from this its U value can be derived.

How to use U values

Key points:

- To calculate the U value of a building element such as a wall, floor or roof, you need to know the build up of that element. Each building material should be positioned properly in sequence. The thickness of each building material also is required.
- The other key property you need to obtain is the conductivity of each building material. This is a measure of its inherent ability to facilitate the passage of heat. It is normally referred to as a 'k value' and values for materials can be found in publications such as the New Metric Handbook and the Architects' Pocket Guide
- The properties of the internal and external faces of the constructional element under scrutiny need to be allowed for. These are called external resistances and are fixed values.
- The U value is defined as being reciprocal of all the resistances of the materials found in the building element.
- The resistance of a building material is derived by the following formula:
  R = (1/k) x d
- where k is the conductivity of the building material and d is the material thickness.
- The formula for the calculation of a U value is
  U(element) = 1 / (Rso + Rsi + R1 + R2 ...)
- where Rso is the fixed external resistance
- where Rsi is the fixed internal resistance
- and R1… is the sum of all the resistances of the building materials in the constructional element. **Answer (B)**

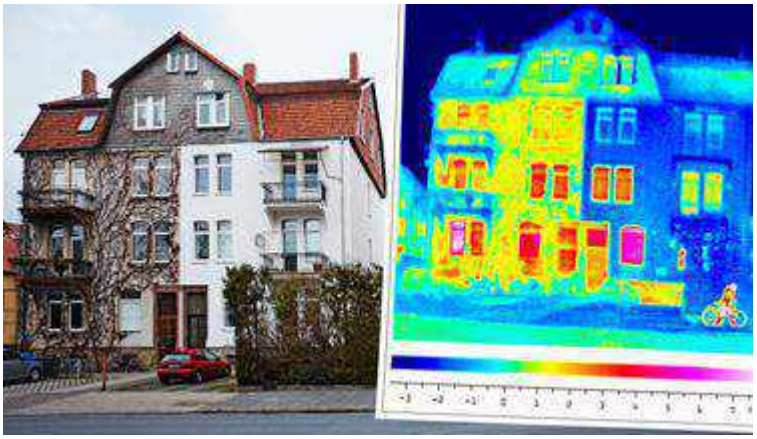

Figure: Infrared imaging.

Q16. Consistency of cement is measured by
(A) Pycometer
(B) Slump cone
(C) Universal Testing Machine
(D) Vicat's apparatus

Q.23 Tile age of a tree is determined by

(A) Counting the number of rings in the stem cross section
(B) Counting the number of leaves on the main branches
(C) Measuring the height of the tree from the rootball
(D) Measuring the canopy circumference of the tree

Notes: Counting the number of rings in the stem cross section. Answer: (A)

Q.24 Nakagin Capsule Tower, Tokyo famous for its spatial modular approach was designed by

(A) Arata Isowi (B) Tadao Ando (C) Kisbo Kuronwa (D) Minoru Yamasaki

Qatar National Conventional Center by **Arata Isowi**

4×4 House II by Tadao Ando

Toyota Stadium by *Kisho Kurokawa*

World Trade Center, New York by **Minoru Yamasaki**

Tadao Ando

Nakagin Capsule Tower

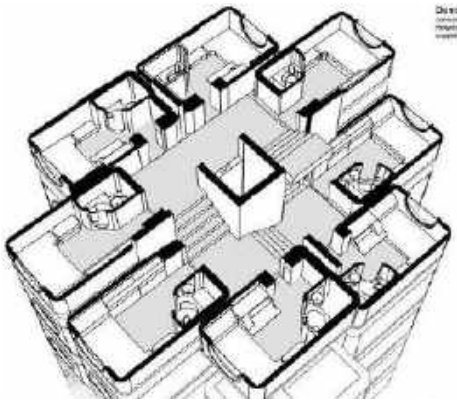

Figure: Nakagin Capsule Tower. The room.

Figure: Nakagin Capsule Tower.

Answer: (C) Kisho Kurokawa

Q.25 Proportioning system used in the layout of Mughal Gardens is derived from

(A) Rational number system
(B) Constants of equilateral triangle
(C) Irrational number system
(D) Constants of right angled isosceles triangle

Answer: (A)

Q.26 - Q.55 carry two marks each,

Q.26 Match the cities in Group I with their form in Group II

Group I	Group II
P. Detroit	1 Star Form
Q.Copenhagen	2. Polycentred Net
R. Stalingrad	3. Linear City
S. San Francisco	4. Ring Form
	5. Galaxy

 Delonix regia	Royal poinciana/Peacock Flower (Gulmohar) **Common name:** Flame Tree, Royal Poinciana • Hindi: Gulmohar गुलमोहर • Bengali: Krishnachura • Kannada: Kempu torai
 Bauhinia purpurea	Mountain Ebony/Purple orchid tree (Kachnar) **Common name:** Butterfly tree, Pink butterfly tree, Purple bauhinia, Purple butterfly tree, Purple orchid tree • Hindi: Kaniar कनियार • Tamil: நீலத்திருவத்தி Nilattiruvatti • Bengali: Koiral • Assamese: Og-yok • Marathi: Rakta chandan • Kannada: Devakanchan
Artocarpus integra	Jack fruit
Butea monosperma Kuntze	Flame of the forest (Palash)
Ficus religiosa	Peepal
Tectona grandis	Teak
Grevillea robusta	Silver Oak
Moringa oleifera	Horse Radish/Drumstick tree
Ficus benghalensis	Banyan
Mangifera indica	Mango Tree
Tamarindus indica	Tamarind tree
Punica granatum	Pomegranate
Psidium guajava	Guava
Ananas comosus	Pineapple
Emblica officinalis	Indian Gooseberry (Amla)
Achras sapota	Chiku
Annona squamosa	Custard Apple (Sitaphal)
Carica papaya	Papaya
Bambusa dendrocalmus	Bamboo
Ocimum tenuiflorum	Basil (Tulsi)

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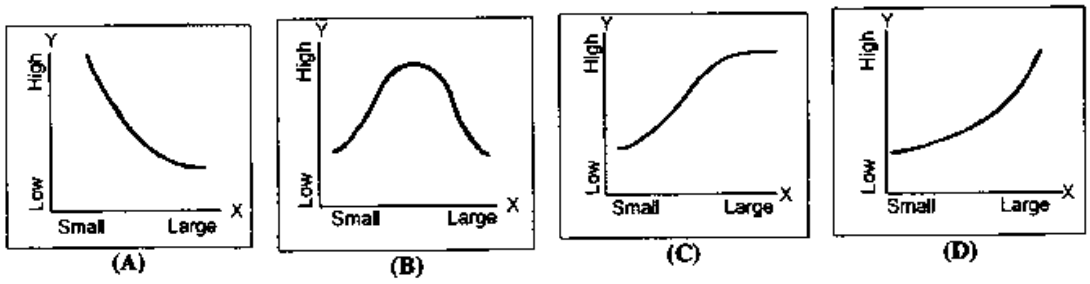
Answer: (C)

Q.29 Following graphs represent the relationship between city size (in terms of population) on X-axis and area under residential use (in percent) on Y-axis. Identify the correct graph.



Answer: (D)

P. loudness of sound at source
Q. Directivity factor
R. length/Width ratio of the enclosure
S. Distance between sound source and listener
U. Sound absorption co-efficient of all enclosing surfaces
V. Surface area of enclosing surfaces
Y. Inside temperature level of the enclosure

(A) P, Q, S, Y, V (B) Q, R, S, U, Y (C) P, R, S, U, V (D) P, Q, S, U, V **Answer: (C)** P, R,S,U,V

Q.35 Match the lamps in Group I with their Colour Rendering Index (CRI) in Group II

Group I	**Group II**
P. Mercury Vapour	1. 65-70
Q. Metal Halide	2. 40-55
R. High-pressure sodium	3. 20-25
S. Low-pressure sodium	4. 60-6

(A) P-4, Q-2, R-1, S-3 (B) P-3, Q-2, R-4, S-1 (C) P- 2, Q - 1, R -4, S – 3 (D) P-4, Q-3, R-2, S -1

Notes: **Color rendering** relates to the way objects appear under a given light source. The measure is called the "color rendering index", or CRI. A low CRI indicates than objects may appear unnatural under the source, while a light with a high CRI rating will allow an object's colors to appear more natural. For lights with a "warm" color temperature the reference point is an incandescent light. For lights with a cool color temperature the reference is sunlight. The table below lists typical color rendering index ratings for a variety of lights, including compact fluorescent light (CFL) bulbs.

CRI		
22	high pressure sodium lighting	street lighting
62	common 4 foot fluorescent tube	office
80-85	compact fluorescent lighting (warm white)	residential
85	premium 4 foot fluorescent tube	retail
80-90	solid state LED lighting	residential
95	incandescent light bulb	residential

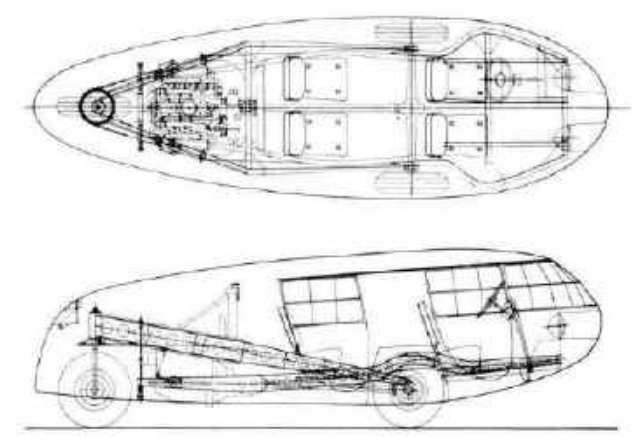
Lights with CRIs of 80 or higher are generally considered to have a high CRI. CRI values should only be compared when the light sources being compared have similar color temperature ratings.

Answer: (C)

Q.36 Match the terms in Group I with the architectural elements in Group II

Group I	**Group II**
P. Tympanum	**l. Auditorium Stage**
Q. Proscenium	**2. Door or Window Bands**
R. Campanile	**3. Circular House**
S. Dymaxion	**4. Church Tower**
	5. Horizontal Space for Services

(A) P-1, Q-3, R-2, S-4
(B) P-2, Q- 3, R -4, S – 1
(C) P-2, Q- 1, R-4, S-3
(D) P-1, Q-2, R-3, S-5



Q.37 Identify the most representative percentage distribution of landuse for a medium urban centre,according to UDPFI guidelines, where

Residential = R. Commercial = C, Transport = T, Industry = I.

(A) R = 30%, C = 20%, T=12%, I=10%
(B) R=45%, C=4%, T=14%, I=8%
(C) R=30%, C=4%, T= 14%, I= 15%
(D) R = 45%, C = 10%, T=12%, I=10% **Answer: (A)**

Q.38 If the area of a plot is 1000 sq.m. area of its adjoining roads is 500 sq.m., maximum permissible FAR is 150 and maximum permissible Ground Coverage is 50%, then utilizing fullest ground coverage and assuming floors of equal area, the number of storeys that can be built on the plot is

(A) 6 (B) 4 (C) 3 (D) 2 **Answer: (C) 3**

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Q.39 Match the buildings in Group I with their architects in Group II

Group I	Group II
P. British Council Library, New Delhi	1. Hasmukh C. Patel
Q. Osho Commune Campus. Pune	2. Charles Correa
R. CII Sohrabji Godrej Green Business Centre, Hyderabad	3. Hafeez Contractor
S. IIM New Campus. Ahmedabad	4. Karan Grover
	5. Balkrishna V. Doshi

(A) P - 1, Q -2, R -3, S – 4 (B) P -2, Q -3, R -4, S -1 (C) P-2, Q-3, R-5, S-1 (D) P -5, Q-4, R -3, S-2

Image: British Council, New Delhi by Charles Correa

Image: Osho Commune Campus. Pune by Hafeez Contractor

GATE SYLLABUS 2018 [Contents covered in this section are highlighted and question no. in superscript] QUESTION PAPER 2009

Section 1: Architecture and Design Visual composition in 2D and 3D; Principles of Art and Architecture; Organization of space; Architectural Graphics[3]; Computer Graphics– concepts of CAD[46], BIM, 3D modeling and Architectural rendition; Programming languages and automation. Anthropometrics; Planning and design considerations for different building types; Site planning[15,48]; Circulation- horizontal and vertical; Barrier free design; Space Standards; Building Codes; National Building Code.

Elements[50], construction[31], architectural styles and examples of different periods of Indian[5,28,40] and Western[37] History of Architecture; Oriental, Vernacular and Traditional architecture[43]; Architectural developments since Industrial Revolution; Influence of modern art on architecture; Art nouveau, Eclecticism, International styles, Post Modernism, Deconstruction in architecture; Recent trends in Contemporary Architecture; Works of renowned national[38] and international architects[30].

Section 2: Building Materials, Construction and Management Behavioral characteristics and applications of different building materials[49] viz. mud, timber, bamboo, brick[2,32], concrete[12,16], steel, glass, FRP, AAC, different polymers, composites.

Building construction techniques, methods[59] and details[60]; Building systems and prefabrication of building elements; Principles of Modular Coordination; Estimation, specification, valuation, professional practice; Construction planning and equipments; Project management techniques e.g. PERT, CPM[1,51,52] etc.

Section 3: Building and Structures Principles of strength of materials; Design of structural elements in wood, steel and RCC[14]; Elastic and Limit State design; Structural systems in RCC[7,57,58] and Steel[20]; Form and Structure[41]; Principles of Pre-stressing; High Rise and Long Span structures, gravity and lateral load resisting systems; Principles and design of disaster resistant structures.

Section 4: Environmental Planning and Design Ecosystem- natural and man-made ecosystem; Ecological principles; Concepts of Environmental Impact Analysis; Environmental considerations in planning and design; Thermal comfort[19], ventilation and air movement; Principles of lighting and illumination; Climate responsive design; Solar architecture[55,56]; Principles of architectural acoustics; Green Building- Concepts and Rating[9]; ECBC; Building Performance Simulation and Evaluation; Environmental pollution- types, causes, controls and abatement strategies.

Section 5: Urban Design Concepts and theories of urban design[13,25,44]; Public Perception[39]; Townscape; Public Realm; Urban design interventions for sustainable development and transportation; Historical and modern examples of urban design[11,22]; Public spaces, character, spatial qualities and Sense of Place[23]; Elements of urban built environment[10,26] – urban form, spaces, structure, pattern, fabric, texture, grain etc; Principles, tools and techniques of urban design; Urban renewal and conservation; Site planning; Landscape design[34]; Development controls – FAR[27], densities and building byelaws.

Section 6: Urban Planning and Housing Planning process; Types of plans - Master Plan, City Development Plan, Structure Plan, Zonal Plan, Action Area Plan, Town Planning Scheme, Regional Plan; Salient concepts[21], theories and principles of urban planning[47]; Sustainable urban development[18]; Emerging concepts of cities - Eco-City, Smart City, Transit Oriented Development (TOD), SEZ, SRZ etc.

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Housing[35,42]; Concepts, principles and examples of neighbourhood; Housing typologies; Slums; Affordable Housing; Housing for special areas and needs; Residential densities; Standards for housing and community facilities; National Housing Policies, Programs and Schemes.

Section 7: Planning Techniques and Management Tools and techniques of Surveys – Physical, Topographical[33], Landuse and Socio-economic Surveys; Methods of non-spatial and spatial data analysis; Graphic presentation of spatial data; Application of G.I.S and Remote Sensing[17] techniques in urban and regional planning; Decision support system and Land Information System.

Urban Economics; Law of demand and supply of land and its use in planning; Social, Economical and environmental cost benefit analysis; Techniques of financial appraisal; Management of Infrastructure Projects; Development guidelines such as URDPFI; Planning Legislation and implementation – Land Acquisition Act, PPP etc.; Local self-governance[6].

Section 8: Services, Infrastructure and Transportation Building Services: Water supply; Sewerage and drainage systems; Sanitary fittings and fixtures; Plumbing systems; Principles of internal and external drainage system; Principles of electrification of buildings; Intelligent Buildings; Elevators and Escalators - standards and uses; Air-Conditioning systems; Firefighting Systems; Building Safety and Security systems.

Urban Infrastructure – Transportation, Water Supply[36], Sewerage, Drainage, Solid Waste Management[24], Electricity[29] and Communications.

Process and Principles of Transportation Planning[45] and Traffic Engineering; Road capacity; Traffic survey methods[8]; Traffic flow characteristics; Traffic analyses and design considerations; Travel demand forecasting; Land-use – transportation - urban form inter-relationships; Design of roads, intersections, grade separators and parking areas; Hierarchy of roads and level of service; Traffic and transport management and control in urban areas,; Mass transportation planning; Para-transits and other modes of transportation, Pedestrian and slow moving traffic planning; Intelligent Transportation Systems. Principles of water supply[4] and sanitation systems; water treatment; Water supply and distribution system; Water harvesting systems; Principles, Planning and Design of storm water drainage system; Sewage disposal methods; Methods of solid waste management - collection, transportation and disposal; Recycling and Reuse of solid waste; Power Supply and Communication Systems, network, design and guidelines. [End]

Q. 1 - Q. 20 carry one mark each.

Q1. The essential difference between CPM and PERT is

(A) Critical Path vs. Critical Activity
(B) Arrow notation vs. Precedence notation
(C) Deterministic approach vs. Probabilistic approach
(D) Project management vs. network Analysis

Introduction: The program evaluation and review technique (PERT) and the critical path method (CPM) are project management techniques used to coordinate activities that contribute to the completion of a complex project. While they are similar, there are key differences relating to the amount of time each technique allocates to each task.

Core Difference: CPM is used for projects that assume deterministic activity times; the times at which each activity will be carried out are known. PERT, on the other hand, allows for stochastic activity times; the times at which each activity will be carried out are uncertain or varied (probabilistic). Because of this core difference, CPM and PERT are used in different contexts.

PERT is used for projects in which activity times are unknown. For example, take a research and development project (R&D). In an R&D project, the amount of time to complete a given task is unpredictable. In such a case, PERT is the best choice, since it allows planners to allocate three estimates for completion times -- the most likely, the most optimistic and the most pessimistic.

CPM: The activities involved in a construction project, on the other hand, are much more predictable, and may not need three estimated completion times. If this is the case, CPM may be more appropriate, since unlike PERT, CPM also allows for planners to make trade-offs between the cost of the project and the amount of time needed to complete it.

Answer: (C)

Q2. The minimum thickness of a wall where single Flemish bond can be used is

(A) Half-brick thick (B) One-brick thick (C) One-and-half-brick thick (D) two-brick thick

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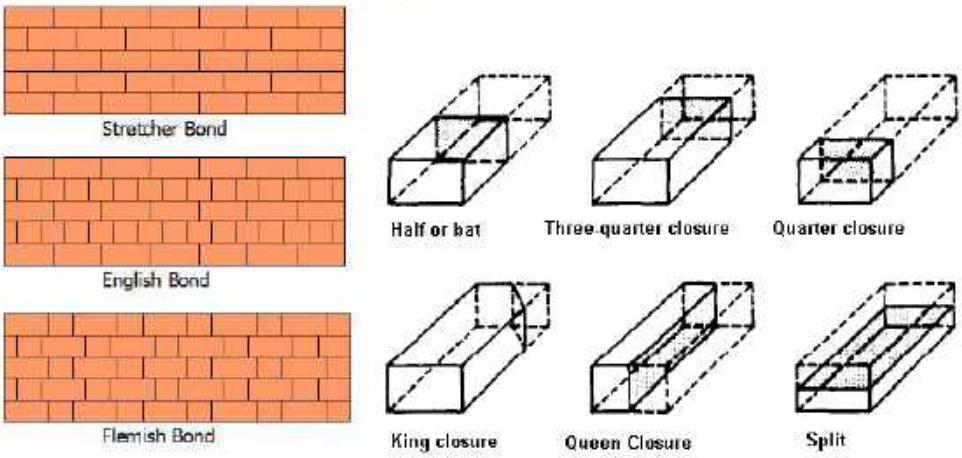
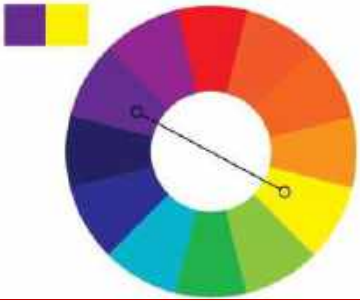


Answer: (B)

Q3. On the colour when, the combination of 'violet-Yellow' or 'Orange-Blue' are bet described as

(A) Complementary (B) Supplementary (C) Analogous (D) Monochromatic

Notes: **Complementary colors** are any two colors which are directly opposite each other, such as red & green and red-purple & yellow-green. These opposing colors create maximum contrast and maximum stability.

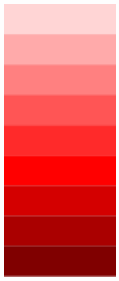


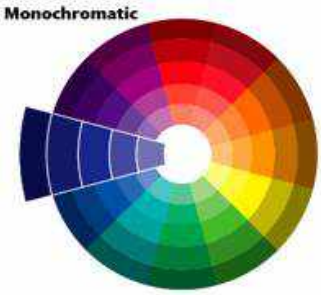
Supplementary colours are colours that are next to each other on the colour wheel. They are basically the colours that are between two prime colours not including the

second prime colour. Example, Red - Red/Orange - Orange - Yellow/Orange are all supplementary to each other.

Analogous colors are groups of colors that are adjacent to each other on the color wheel, with one being the dominant color, which tends to be a primary or secondary color, and two on either side complimenting, which tend to be tertiary. The term analogous refers to the having analogy, or corresponding to something in particular.

Monochromatic colors are all the colors (tints, tones, and shades) of a single hue. Monochromatic color schemes are derived from a single base hue, and extended using its shades, tones and tints (that is, a hue modified by the addition of black, gray (black + white) and white. As a result, the energy is more subtle and peaceful due to a lack of contrast of hue.

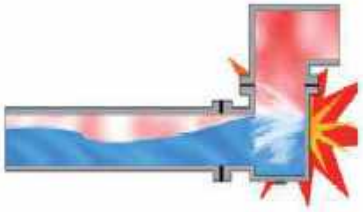




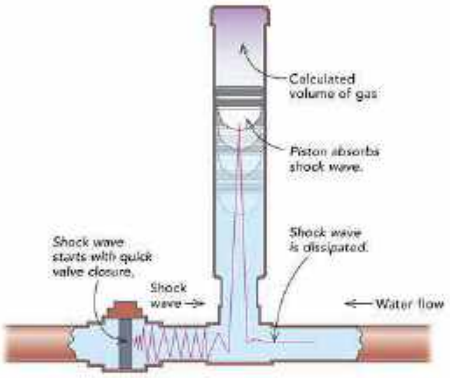
Answer: (A)

Q4. The sudden stoppage in the flow of water in a closed conduit results in a phenomenon called

(A) Cavitation (B) Hydraulic gradient (C) Stack pressure (D) Water hammer



Notes: **Water hammer** (or, more generally, fluid hammer) is a pressure surge when a fluid (usually a liquid but sometimes also a gas) in motion is forced to stop or change direction suddenly (momentum change). A water hammer commonly occurs when a valve closes suddenly at an end of a pipeline system, and a pressure wave propagates in the pipe. It is also called hydraulic shock.



This pressure wave can cause major problems, from noise and vibration to pipe collapse. It is possible to reduce the effects of the water hammer pulses with accumulators, expansion tanks, surge tanks, and other features.

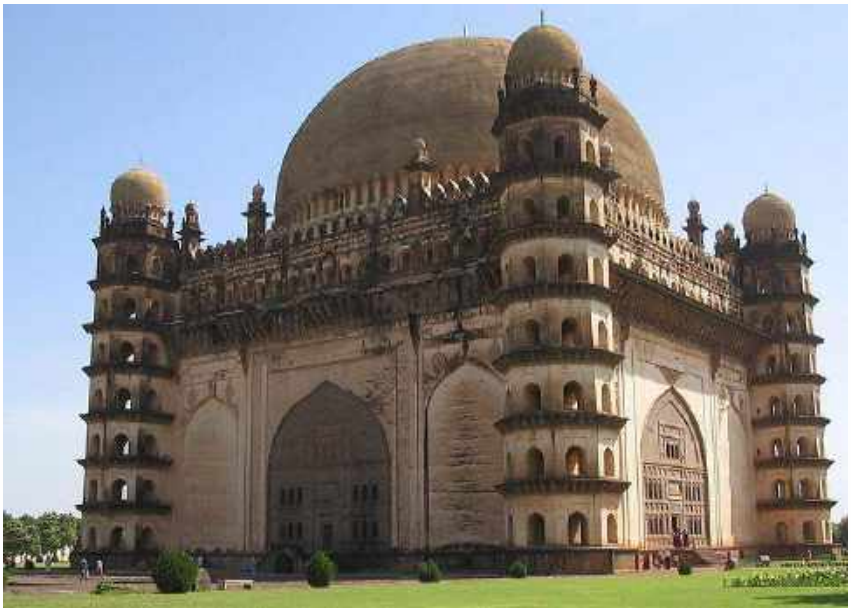
When a pipe is suddenly closed at the outlet (downstream), the mass of water before the closure is still moving, thereby building up high pressure and a resulting shock wave. In domestic plumbing this is experienced as a loud banging, resembling a hammering noise. Water hammer can cause pipelines to break if the pressure is high enough. Air traps or stand pipes (open at the top) are sometimes added as dampers to water systems to absorb the potentially damaging forces caused by the moving water.

In the home, water hammer may occur when a dishwasher, washing machine, or toilet shuts off water flow. The result may be heard as a loud bang, repetitive banging (as the shock wave travels back and forth in the plumbing system), or as some shuddering.

The simple solution is to install a manufactured water hammer arrester; a small sealed air chamber that's designed to prevent water hammer. **Answer: (D)**

Q5. The number of intersecting arches that support Bijapur's Gol Gumbaz is

(A) 4 (B) 8 (C) 12 (D) 16



Notes: "Eight intersecting arches created by two rotated squares that create interlocking

party in the appropriate techniques and processes towards building a green building. It was designed as a point based system to give the interested party an approximation of how green the building would be.

The Energy and Resources Institute, also known as **TERI** (formerly Tata Energy Research Institute), established in 1974, is a research institute that conducts research work in the fields of energy, environment and sustainable development with a focus on formulating local- and national-level strategies for shaping global solutions to critical issues. **Answer: (A)**

Q10. A 'cul-de-sac' is a street where

(A) Only two-wheelers are permitted
(B) Through traffic is discouraged
(C) Pedestrians are not permitted
(D) Vehicles are permitted to move in one direction only

A *culdesac* or *cul-de-sac* is a dead end *street*. It is a *street* that is not connected to other *roads*, and it provides both way in and out of an area. Cul-de-sacs discourage mobility and increase dependence on cars to get around. **Answer: (B)**

Q11. 'Usonian' houses were designed by

(A) Mies van der Rohe (B) Alvar Aalto (C) Frank Lyoyd Wright (D) Le Corbusier

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Definition: In 1936, when the United States was in the depths of an economic depression, American architect Frank Lloyd Wright developed a series of homes he called *Usonian*. Designed to control costs, Wright's Usonian houses had no attics, no basements, and little ornamentation. Some have said that the word *Usonia* is an abbreviation for *United States of North America*. Affordable house for the "common people" of the United States.

Characteristics: Usonian architecture grew out of Frank Lloyd Wright's earlier Prairie style homes. Both styles featured low roofs and open living areas. Both styles made abundant use of brick, wood, and other natural material. However, Wright's Usonian homes were small, one-story structures set on concrete slabs with piping for radiant heat beneath. The kitchens were incorporated into the living areas. Open car ports took the place of garages.

In the 1950s, when he was in his '80s, Frank Lloyd Wright first used the term *Usonian Automatic* to describe a Usonian style house made of inexpensive concrete blocks. The three-inch-thick modular blocks could be assembled in a variety of ways and secured with steel rods and grout. Frank Lloyd Wright hoped that home buyers would save money by building their own Usonian Automatic houses. But assembling the modular parts proved complicated - most buyers hired pros to construct their Usonian houses.

Frank Lloyd Wright's Usonian architecture played an important role in the evolution of America's Mid-century homes. But, despite Wright's aspirations toward simplicity and economy, Usonian houses often exceeded budgeted costs. Like all of Wright's designs, Usonians became unique, custom homes for families of comfortable means.

Answer: (C)

Q12. Increase in the volume of fine aggregate due to the pressure of moisture is called

(A) Bulking (B) Buckling (C) Bending (D) Twisting

Notes: ***Bulking of sand means increase in it's volume due to presence of surface moisture . The volume increases with increase in moisture content . The volume may increase up to 20 to 40% when moisture content is 5 to 10 %.*** To be more precise, due to moisture in each particle of sand, sand gets a coating of water due to surface tension which keeps the particles apart. This causes an increment in volume of sand known as Bulking. **Answer: (A)**

Q13. The pattern Language theory was propounded by

(A) Christopher Alexander (B) Patrick Geddes (C) John Ruskin (D) Amos Rapoport

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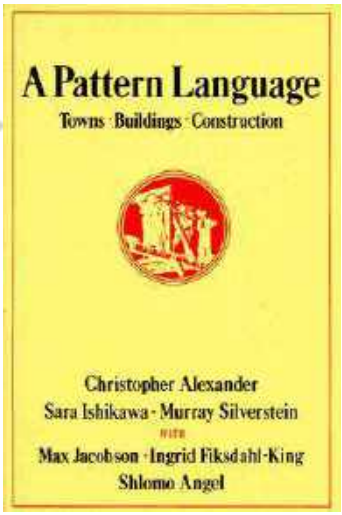


Notes: Christopher Alexander earned a Bachelor's degree in Architecture and a Master's degree in Mathematics.

A Pattern Language: Towns, Buildings, Construction (1977) described a practical architectural system in a form that a theoretical mathematician or computer scientist might call a generative grammar.The work originated from an observation that many medieval cities are attractive and harmonious. The authors said that this occurs because they were built to local regulations that required specific features, but freed the architect to adapt them to particular situations.

The book provides rules and pictures, and leaves decisions to be taken from the precise environment of the project. It describes exact methods for constructing practical, safe and attractive designs at every scale, from entire regions, through cities, neighborhoods, gardens, buildings, rooms, built-in furniture, and fixtures down to the level of doorknobs.

A notable value is that the architectural system consists only of classic patterns tested in the real world and reviewed by multiple architects for beauty and practicality. **Answer: (A)**

Q14. As per IS:456-2000, the maximum area of tension reinforcement in a RCC beam shall not exceed x% of its cross-sectional area, where x is equal to

(A) 2 (B) 4 (C) 6 (D) 8 **Answer: (A)**

Q15. 'No-cut no-fill' lines are mostly used in

(A) Land use planning (B) Interpretation of stereo-vision photographs

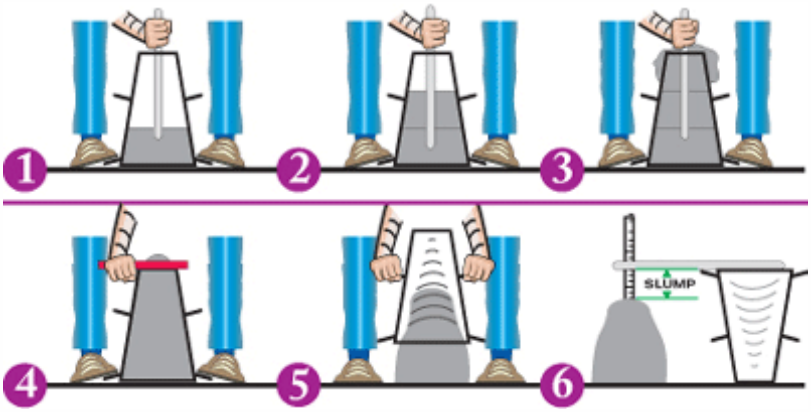
(C) Earthwork computation (D) Interpretation of remotely sensed images

You might have learned in Site-Planning classes! **Answer: (C)**

Q16. The property of concrete measured by the Slump Test is

(A) Durability (B) Hardness (C) Strength (D) Workability

Notes: Slump test is used to determine the workability of fresh concrete. or fluidity. It's an indirect measurement of concrete consistency or stiffness.



The consistency, or stiffness, indicates how much water has been used in the mix. The stiffness of the concrete mix should be matched to the requirements for the finished product quality. The test is popular due to the simplicity of apparatus used and simple procedure. **Answer: (D)**

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17. The Remote sensing satellite that gives the highest spatial resolution is

(A) IKONOS 2 (B) IRS 1C/1D (C) Quickbird 2 (D) SPOT 5

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Notes: **IKONOS 2** is a commercial earth observation satellite, and was the first to collect publicly available high-resolution imagery at **1- meter resolution**. Supposedly a variant of the Greek word `eikon' (icon), meaning "image."
IRS-1C/1D was a remote sensing Indian satellite with **5.8-meter** resolution.
QuickBird II was launched October 18, 2001 from an Air Force Base, California, USA. It was able to produce **0.61 meter resolution** imaginary.
SPOT 5 was launched on May 4, 2002 with **2.5 meter resolution** capability. **Answer: (C)**

Q18. Development that meets the needs of the present generation without compromising the ability of future generations to met their own needs is termed by UNDP is

(A) Comprehensive Development
(B) Equitable Development
(C) Human Development
(D) Sustainable Development

Notes: **Sustainable development** is "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable development promotes the idea that social, environmental, and economic progress are all attainable within the limits of our earth's natural resources. Sustainable development approaches everything in the world as being connected through space, time and quality of life.

Sustainable development constantly seeks to achieve social and

The Stadium, designed by Swiss Jacques Herzog and Pierre de Meuron in collaboration with ArupSport and China Architecture Design & Research Group, won the international convened in 2002 precisely because the original settlement proposal, inspired by the plot of a nest and made up a myriad of twigs and entanglement, managed to impress a jury which included professional and impressive Koolhaas, Nouvel and Perrault. The project received a budget of $500 million dollars.

The Olympic Stadium in Beijing was the view of the architects "brilliant aesthetic and structural challenges".

Concept: The stadium design was inspired by the formation of nesting birds. The architects have succeeded in translating the concept, so that their work on the project soon gained the nickname "bird's nest" almost spontaneously among the Chinese population.

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The design is based on the nests of birds, not only aesthetically but also at a structural level. The entire structure, visible from the outside, mirrors the branches of the nests that working together with each other achieve unimaginable resistance to the elements. At the center of the area that also houses other Olympic structures, the stadium seems to be perched like a spaceship, with a quiet majesty whose appeal is given by its slight undulation.

Spaces: What makes this even more complex project is the fact that the "nest" is not only walls and roof, but also houses the stairs and facade.

The domestic routes are "marked" by elements of spaced sotillos of slate and bamboo, stone blocks and covered gardens that reflect some of the symbols of Chinese culture.

Structure and Materials: The stadium is 330 meters long, 220 meters wide and 69 meters high.

The protagonist between the materials is the steel that constitutes the various branches of the nest, between one and another, a series of "cushions" of inflatable ETFE (ethylene-copolymer tetrafluoretileno) give the stadium a "quilted" image. The cost of this large area of material used for the cover was $8 million.

Besides the aesthetic value of this network, we must emphasize the role of the structural elements of metal, which are interlacing and are mutually supporting. Although it produces the impression of a casual and almost natural course, the meeting of the various elements and the direction we take in the nest, are the result of precise calculations.

The steel structure had to be supported by 176 hydraulic jacks during its construction while the structure was not capable of self-sustainment. Each crane was capable of holding 300 tons, each with an accuracy of one millimeter. Later,

the hydraulic jacks were removed at once to check the stability of the structure of the stadium.

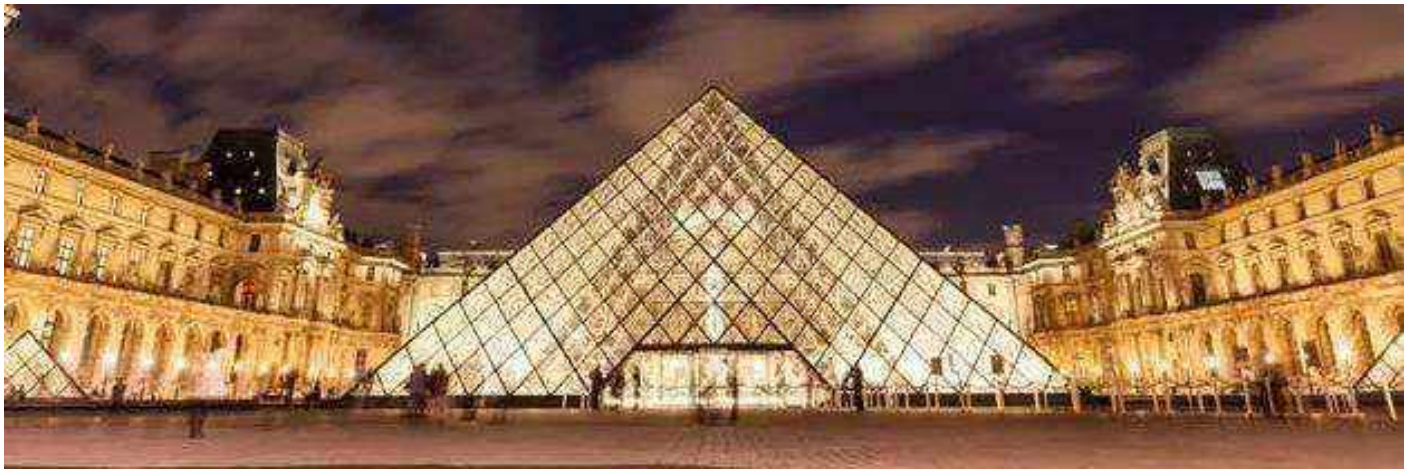
The special features of this stadium, which was the main stage of the 2008 Olympics, suggest it being completely closed. In fact, in correspondence with the central area, the ceiling is a transparent membrane, through which passes the light from outside. The remaining part of the structure is covered by a translucent layer that protects it from adverse weather and a second layer of acoustic insulation.

To the architecture of Herzog & de Meuron, attentive to the materials and implementing new solutions, this project has also become an opportunity for experimentation and research, both during the "creative" stage as during its work.

……

The Louvre Pyramid design by IM Pei was one of the controversial project. As soon as word leaked that a modern pyramid would be built at the heart of the Louvre, most critics were quick to attack the audacious design. The plans also caused an outcry with Parisians, who had become weary of modern projects after the construction of theMontparnasse Tower and the bland towers of La Défense. Polls indicated a large majority of the French citizens opposed the structure. But soon after the official inauguration of the pyramid in March 1989, the opposition quickly subsided and the Louvre Pyramid became one of Paris's most beloved modern landmarks.

The Design: The pyramid is rather modest in size compared to the surrounding palace wings of the Louvre. It has a height of about 22 meters (72ft) and at its base measures just over 35 meters (116ft). It is flanked by three smaller pyramids and reflecting pools with modern fountains.



Much effort was made to make the pyramid as transparent as possible. The 675 diamond-shaped and 118 triangular panes were specifically fabricated to make them completely clear. Attention was also paid to the 128 steel girders and 16 steel cables that hold the panes together. Technology from high tech yachts was used to make them as small and unobtrusive as possible.

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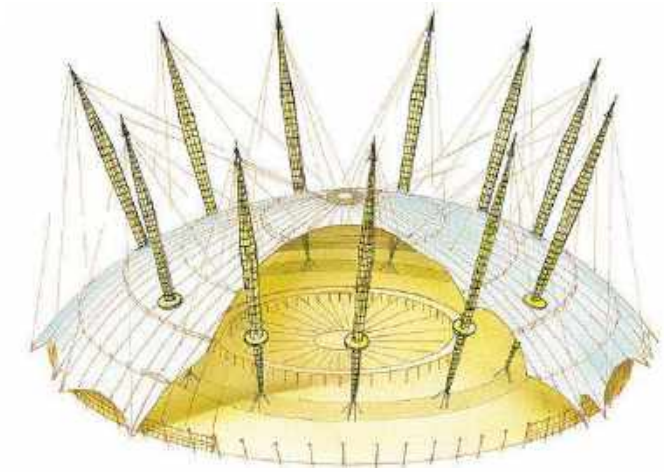
The **Millennium Dome** was constructed to be the home of a very large exhibition that was to celebrate the coming of the third millennium.

Architect: The Millennium Dome was designed by Richard Rogers. Rogers is known around the United Kingdom for his very functional, semi-modernist design flair. He has worked on the Lloyd's Building, and the Court of Human Rights building that is in Strasbourg. He has won the Thomas Jefferson Medal, the Minerva Medal, the RIBA Stirling Prize, and the Pritzker Prize in recognition of his architectural achievements.



Design and Construction: The building is constructed out of tensioned fabric over a skeleton of steel. Of the many large domes worldwide which share this construction scheme, the Millennium Dome is one of the largest. Symbolism is key to the design of the dome and there are many symbolic pieces of the structure. It has 12 supports that jut out from the cloth ceiling that represent the months of the year and the hours on a clock face. This is an attempt to pay homage to the role of Greenwich Mean Time since the Prime Meridian passes just to the west of the building. The circular dome also has a diameter of 365 metres to represent the days of the year. The centre of the dome is a full 52 metres tall to represent the 52 weeks in each year. The top of the structure is comprised of a thick glass/fibre fabric that has been coated with PTFE. It is a very durable material that is commonly used in similarly styled buildings. Due to the fact that the roof is held together using 12 struts, the building is not technically a "dome" by architectural standards. The roof was designed to actually be lighter than the air inside of the building. This helps its structural integrity significantly.

History:The land upon which the Millennium Dome sits was once heavily contaminated by toxic runoff and waste from the East Greenwich Gas Works. The Millennium Dome was originally supposed to be much smaller than it turned out to be and was meant to be a conservatively-sized exhibition. In 1997, the Labour government pushed the size and scope of the proposed dome to its limits and led to the development of the enormous structure that exists today. It was decided that the project would be both a reclamation effort of the Greenwich Peninsula and an enormous celebration of the coming of the new millennium.

Current Use: After the failure of the Millennium Exhibition and the resulting scandal over the cost of the Millennium Dome, the dome was sold and has been rebranded as O2 Arena. It is a major exhibition and events venue in London that often hosts concerts by famous bands.

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Kansai International Airport (KIX) is the world's first ocean airport, built on a landfill island in Osaka Bay, Japan. Opened in 1994, KIX was a modern engineering marvel, built entirely as an artificial island. Because the site is built upon compacted fill, it suffers from subsidence, sinking 2-4 centimeters per year. KIX is linked to the mainland by a 3.7-kilometer bridge, and provides air service for the nearby cities of Osaka, Kobe, and Kyoto.

Four months after opening, the airport was severely tested by the magnitude 6.7 Kobe earthquake; it survived with only minor damage, and provided continuous operation during the relief efforts.

Kansai International Airport Terminal, Osaka, Japan, Renzo Piano. The longest terminal in the world

KIX has a single four-storey terminal designed by Renzo Piano Building Workshop (Renzo Piano and Noriaki Okabe). It is the longest airport terminal in the world, at a total length of 1.7 km from end to end: a sophisticated people mover system called Wing Shuttle moves passengers from one end of the pier to the other.

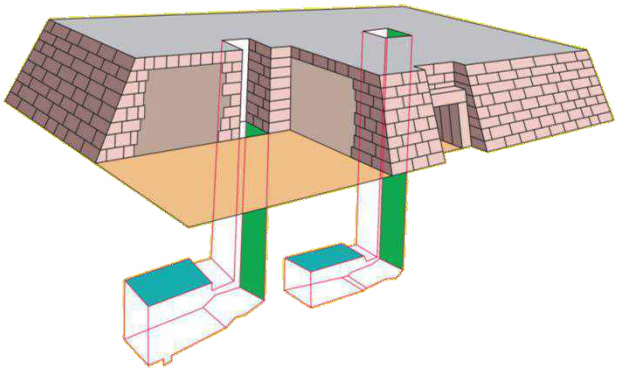
The terminal's roof is shaped like an airfoil. This shape is used to promote air circulation through the building: giant air conditioning ducts blow air upwards at one side of the terminal, circulate the air across the curvature of the ceiling, and collect the

air through intakes at the other side. Mobiles are suspended in the ticketing hall to take advantage of the flowing air.
Answer: (C)

Q31. Identity the 'pre-historic' structures in the following:

P. Mastaba Q. Dolmen R. Menhir S. Pylon T. Stonehenge U. Thermae	(A) P, Q, R (B) R, T, U (C) Q, S, T (D) Q, R, T

Notes: Egyptologist use the Arabic word 'mastaba', meaning 'bench', for the massive rectangular structures found above many tombs in Saqqara, Gizeh and other places. They often have rooms for offerings inside which are decorated with reliefs or paintings. In the Old Kingdom (about 2686-2181 BC) they had a separated room 'serdab' in which one or more statues of the tomb owner and his family were placed. The earliest mastabas are found at Tarkhan, Saqqara and Gizeh. They are structures decorated with a palace facade.



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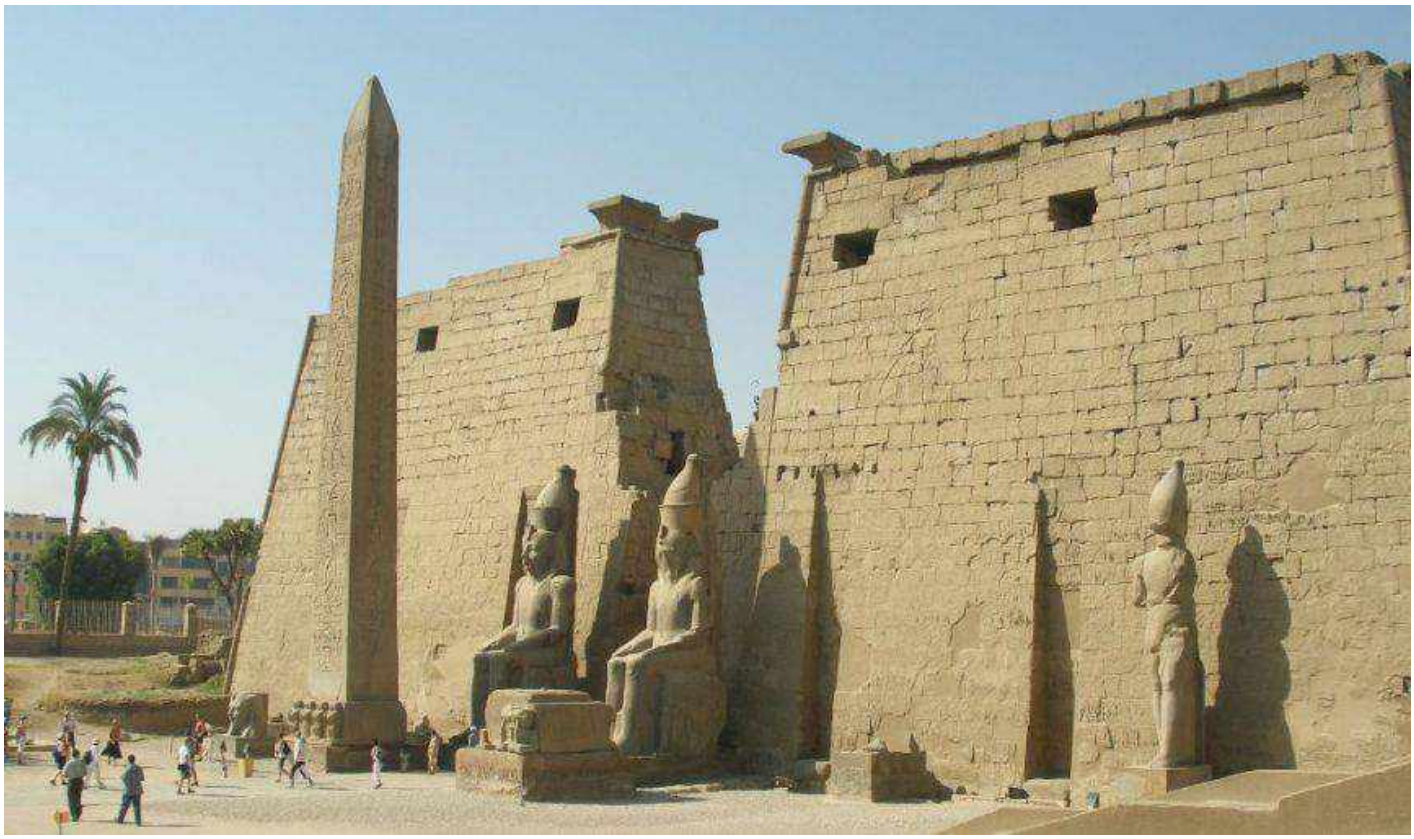
Example: In the Golan heights area there are hundreds of **dolmens** (prehistoric megalith tombs), which were erected at the early middle bronze period (about 30 C BC). The tombs may have been of nomad tribes who buried their dead in central holy places. Some of the dolmens were reused for secondary burials long after they have been erected.



Pylons were monumental gateways to ancient *Egyptian temples.*

Thermae, complex of rooms designed for public bathing, relaxation, and social activity that was developed to a high degree of sophistication by the ancient Romans. Although public baths are known to have existed in early Egyptian palaces, remains are too fragmentary to permit complete analysis of Egyptian types. Bathing occupied an important place in the life of the Greeks, as indicated by the remains of bathing rooms in the palace of Knossos (begun *c.* 1700 bc). The standardized architectural type of the thermae, however, was not developed until the Romans designed the great imperial thermae.

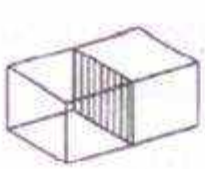
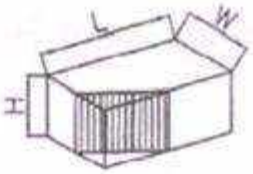
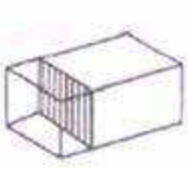
……

Stonehenge is a prehistoric, mysterious circle of upright stones in southern England. Construction on the great monument began 5,000 years ago; the famous stones that still stand today were put in place about 4,000 years ago.

The stones are aligned almost perfectly with the sunrise on the summer solstice, and it is almost unquestioned that Stonehenge was built as a spectacular place of worship.

Although the faith of the Stonehenge builders predates any known religion, the site has become a place of pilgrimage and worship for Neopagans who identify themselves with the Druids or other forms of Celtic paganism. It is also popular with New Age devotees, who report powerful energies at the site. **Answer: (D)**

Q32. Match the figures of cut bricks in Group I with their terms in Group II:

Group I	Group II
P  Q  R  S 	1. King Closer 2. Queen Closer 3. Half Bat 4. Three Quarter Bat

(A) P - 2, Q - 3, R - 1, S - 4
(B) P - 2, Q - 1, R - 3, s - 4
(C) P - 1, Q - 2, R - 4, S - 3
(D) P - 3, Q - 4, R - 1, S – 2

Answer: (A)

Advantages:
- Very efficient lamp
- Powerful lamp for use of large areas
- Despite a warm up time of 5-10 minutes it restarts immediately if there is a brownout
- Lumen output does not drop with age (such as in LEDs or incandescents)

Disadvantages:
- Worst color rendering of any lamp
- Sodium is a hazardous material which can combust when exposed to air (such as if the bulb is broken in the trash)

Statistics:
CRI -44
Color Temperature: 1800
100-190 lumens per watt
Bulb life: 18,000 hrs

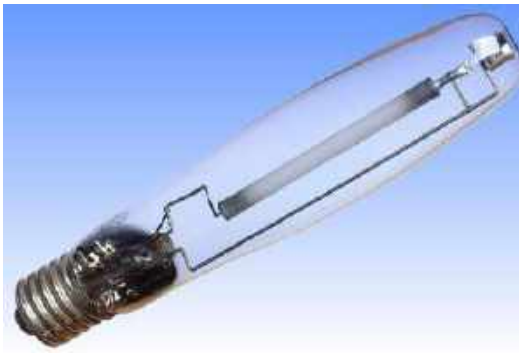


Figure: **High Pressure Sodium Lamp** is widely used in street lighting but now a days LED lighting takes the space as LED is highly efficient.

High Pressure Sodium Lamp (HPS Lamp)

The HPS lamp is the most ubiquitous lamp for street lighting on the planet. The lamp is an improvement over the LPS lamp in that it has more acceptable color with the great efficiency of the sodium lamp. The better color rendering comes with a bit of sacrifice, it has less efficiency than the LPS. General Electric first developed the lamp in Schenectady, New York and Nela Park, Ohio. The first lamp came on the market in 1964.

Advantages:
-Good efficiency (lumens per watt)
-Smaller size than LPS or fluorescent, the HPS fits into many fixture types
-Can be retrofitted into older Mercury Vapor fixtures
-Better bulb life than LPS lamps

Statistics:
CRI 20-30
80-140 lumens per watt
Bulb Life: 24,000 hrs

Disadvantages:
-Still has a bad color rendering compared to metal halide and halogen lamps
-Requires a lossy ballast (inefficient) that operates a low arc voltage of 52-100V. This reduces the actual efficiency of the lamp when you count the whole system together.

(Source: http://www.edisontechcenter.org/SodiumLamps.html)

1.4 A method of Control survey, in which a network of triangles is used in

(A) **Triangulation**
(B) Three-point resection
(C) Trilateration
(D) None of these

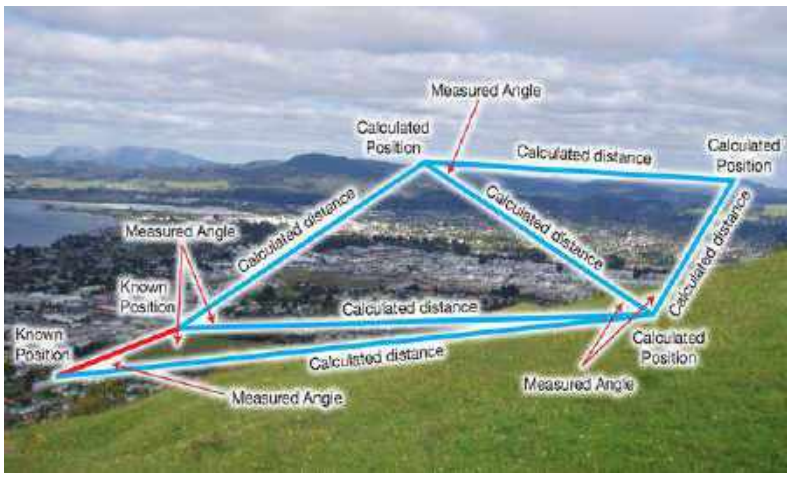


Figure: Triangulation Network.

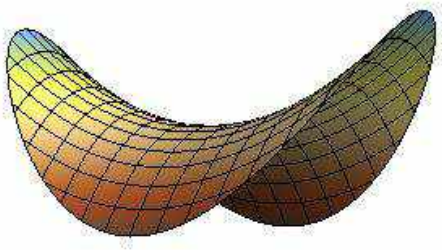
Notes: Triangulation is a surveying method that measures the angles in a triangle formed by three survey control points. Using trigonometry and the measured length of just one side, the other distances in the triangle are calculated. The shape of the triangles is important as there is a lot of inaccuracy in a long skinny triangle, but one with base angles of about 45 degrees is ideal.

1.5 Hyperbolic paraboloid can be generated by

(A) a curve moving over two straight lines at obtuse angles

(B) a straight line moving over curve at acute angle
(C) a curve moving over two other parallel curves
(D) a straight line moving over two other straight lines at an angle to one another

A hyperbolic paraboloid (sometimes referred to as 'h/p') is a doubly-curved surface that resembles the shape of a saddle, that is, it has a convex form along one axis, and a concave form on along the other. It is also a doubly-ruled surface, that is, every point on its surface lies on two straight lines across the surface. Horizontal sections taken through the surface are hyperbolic in format and vertical sections are parabolic.
(Source: https://www.designingbuildings.co.uk/wiki/Hyperbolic_paraboloid_in_construction)


1.6 'Savannas' are
(A) grasslands with draught-resistant trees
(B) parts of arctic regions with moving glaciers
(C) estuaries, where delta is formed
(D) parts of desert with perennial water pockets

The most common definition of *savanna* is the tropical grassland, such as in Africa. They have seasonal rains and dry periods. All *savanna* plants and trees can survive periods of drought. Most *savannas* get enough rain to support a forest, but the forest never happens because something keeps the trees from growing.

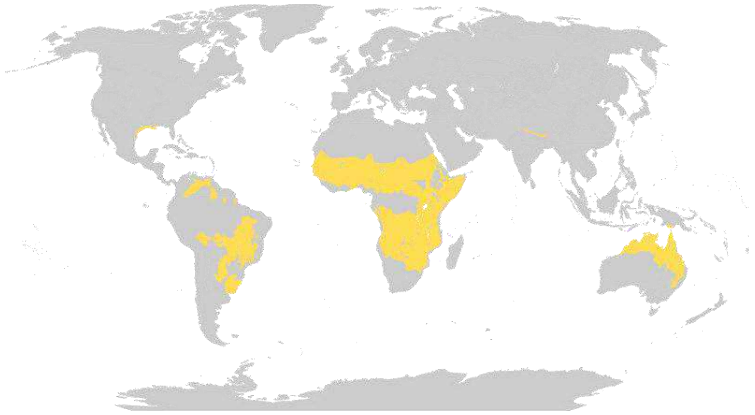


Figure: **'Savannas' grasslands** across the globe.

Figure: **'Savannas' grassland in Africa**

Duration: 3 hours
Maximum marks: 150
Instruction: Choose either part I or part II from Section B. Section B has TWENTY questions. Answer any TEN questions in this section.
Special instruction would be provided at the beginning of the question if any. **No negative marking.**

SECTION A (100 marks)

SUBSECTION A1 (75 marks)

SECTION A (100 Marks)

1. Write in your answer book the correct or the most appropriate answer to the following questions. (20 x 1 = 20 marks)

1.1 The visual principle of optical correctness was invented and used in
(A) Byzantine Architecture (B) Islamic Architecture (C) Gracco Roman Architecture (D) **Greek Architecture**

1.2 Interface of two ecological zones is termed as
(A) Ecosystem **(B) Ecotone** (C) Profile (D) Promontories

Ecology

- Ecology may be defined as the scientific study of the relationship of living organisms with each other and with their environment
- The emphasis is on relationships between organisms and the components of the environment namely abiotic (non-living) and biotic (living).
- Ecology is derived from 2 Greek words
- **Oikos** >> Home or place to live in
- **Logos** >> Study
- Literally, it means study of home or nature
- Ecology not only deals with the study of the relationship of individual organisms with their environment, but also with the study of populations, communities, ecosystems, biomes and biosphere as a whole

Biome

- a large community unit, characterized by a major vegetation type and associated fauna, found in a specific climatic region
- No two biomes are alike

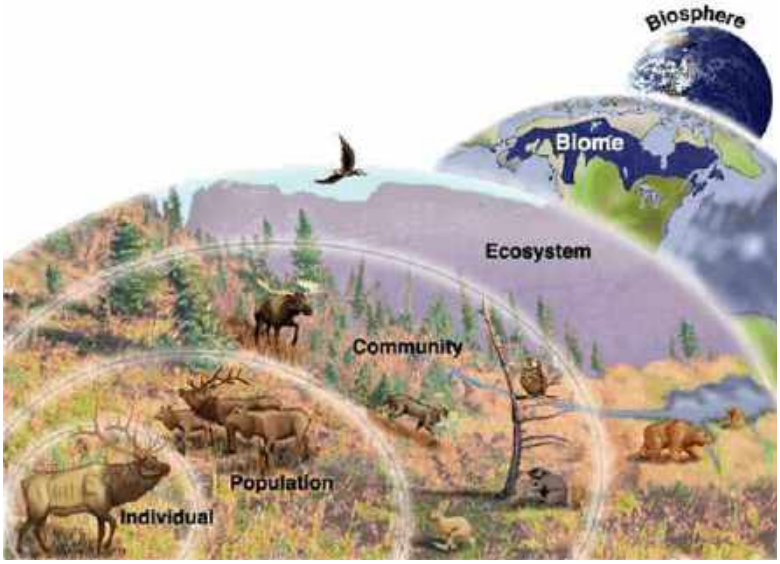


Figure: formation of Biome

Ecotone

- Transitional area between two biomes or diverse ecosystems (where two communities meet & integrate)
- Examples : between a field and forest, between forest and grassland
- may appear as a gradual blending of the two communities across a broad area, or may manifest itself as a sharp boundary line
- May contains some organisms which are entirely different from that of adjoining communities
- Sometimes the number of species & population density of some of the species is much greater in this zone than either community, Known as **edge effect**

1.17 The principle of 'Conservative Survey' was suggested by
(A) Oscar Neimeyer (B) **Patricks Geddes** (C) Charles Abraham
(D) Lewis Mumford

1.18 Plant which can block wind and view throughout the year when branching very near the ground are
(A) Deciduous
(B) **Evergreen Conifers**
(C) Broad leaf evergreens
(D) Mixed evergreen deciduous

Deciduous means "falling off at maturity" or "tending to fall off", and it is typically used in order to refer to trees or shrubs that lose their leaves seasonally (most commonly during autumn) and to the shedding of other plant structures such as petals after flowering or fruit when ripe.

Figure: **Evergreen Conifers** can block wind and view throughout the year when branching very near the ground.

1.19 The Tien An Mein Square in Peking is an example of
(A) Ornamental Park (B) Shopping Center
(C) **Large Plaza** (D) Exhibition ground

1.20 The National Commission on Urbanisation was chaired by
(A) Rajiv Gandhi
(B) **Charles Correa**
(C) B. V. Doshi
(D) A. P. Kanvinde

2. What do the following abbreviations stand for: (10 x 1 mark = 10 marks)
(A) BTU (British Thermal Unit)
(B) HVAC (Heating Ventilation & Air Conditioning)

1.1 The delay in transfer of thermal energy from outside to inside is called
(A) Thermal conductivity (B) Insulation (C) Radiation (D) Thermal lag

Thermal lag is the delay of heat transmitted through a wall. It's a measurement of the ability of walling material to slowly absorb and release heat energy. A material with high heat capacity and low conductivity will have a high thermal lag. Thermal lag times are influenced by:

- Temperature differentials between each face.
- Exposure to air movement and air speed.
- Texture and coatings of surfaces.
- Thickness of material.
- Conductivity of material.

Thermal lag can be used to ease out internal/external diurnal temperature variations. Materials for example, bricks and other heavyweight materials offer this property. Thermal lag can be measured as the amount of time taken for a material to absorb and then release the heat energy. Units for measuring thermal lag is generally in Hours. In temperate climates, external wall materials with a minimum time lag of 10 to 12 hours can be very effective to reduce internal/external temperature variations during day and night. If it is required to keep the heat for a longer time, a layer of insulation can be added to slow the rate of heat transfer and moderate temperature differentials. Answer: (D)

1.2 Flying buttresses were used in
(A) Egyptian Architecture (B) Greek Architecture (C) Gothic Architecture (D) None of the above

Gothic architecture, architectural style in Europe that lasted from the mid 12th century to the 16th century, particularly a style of masonry building characterized by cavernous spaces with the expanse of walls broken up by overlaid tracery. In the 12th–13th centuries, feats of engineering permitted increasingly gigantic buildings. The **rib vault, flying buttress, and pointed (Gothic) arch** were used as solutions to the problem of building a very tall structure while preserving as much natural light as possible. Stained-glass window panels rendered startling sun-dappled interior effects. One of the earliest buildings to combine these elements into a coherent style was the abbey of Saint-Denis, Paris (c. 1135–44). The High Gothic years (c. 1250–1300), heralded by Chartres Cathedral, were dominated by France, especially with the development of the Rayonnant style. Britain, Germany, and Spain produced variations of this style, while Italian Gothic stood apart in its use of brick and marble rather than stone. Late Gothic (15th-century) architecture reached its height in Germany's vaulted hall churches. Answer: (C)

1.3 PERT Analysis is based on:
(A) Optimistic time (B) Pessimistic time (C) Most likely time (D) All the above.

PERT (Program Evaluation and Review Technique) is a variation on Critical Path Analysis that takes a slightly more skeptical view of time estimates made for each project stage. To use it, estimate the shortest possible time each activity will take, the most likely length of time, and the longest time that might be taken if the activity takes longer than expected. This helps to bias time estimates away from the unrealistically short time-scales normally assumed. Answer: (D)

$$\text{Estimated Time} = \frac{\text{shortest time} + 4 \times \text{likely time} + \text{longest time}}{6}$$

1.4 '*Shikhara*' refers to
(A) Prayer hall (B) Tower above main chamber of God
(C) Crown of Minaret (D) Hall of offerings

The basic form of a Hindu structural temple consists of: Garbhagriha, Mandapa, Shikhara or Vimana, Amalaka, Kalasha, Antarala (vestibule), Jagati, Vahana and others.

1. Garbhagriha:

- It literally means 'womb-house' and is a cave like a sanctum.
- In the earliest temples, it was a small cubical structure with a single entrance.
- Later it grew into a larger complex.
- The Garbhagriha is made to house the main icon (main deity) which is itself the focus of much ritual attention.

2. Mandapa:

- It is the entrance to the temple.
- It may be a portico or colonnaded (series of columns placed at regular intervals) hall that incorporates space for a large number of worshippers.
- Dances and such other entertainments are practiced here.
- Some temples have multiple mandapas in different sizes named as Ardhamandapa, Mandapa, and Mahamandapa.

3. Shikhara or Vimana: North Indian style of temple architecture is called Nagara and south Indian style is Dravidian. In Dravidian style the tower section is called **vimana**. In Nagara style the tower section is called **shikara**.

- They are mountain like the spire of a free-standing temple.

Figure: Shikhara has a curving shape while vimana has a pyramidal-like structure

4. Amalaka:

- It is a stone disc like structure at the top of the temple and they are common in North Indian temples.

5. Kalasha:

- It is the topmost point of the temple and commonly seen in North Indian temples.

6. Antarala (vestibule):

- Antarala is a transition area between the Garbhagriha and the temple's main hall (mandapa).

7. Jagati:

- It is a raised platform for sitting and praying and is common in North Indian temples.

8. Vahana:

- It is the mount or vehicle of the temple's main deity along with a standard pillar or **Dhvaj** which is placed axially before the sanctum. Answer: (B)

1.5 Guggenheim museum is in:

(A) New York (B) Copenhagen (C) London (D) Philadelphia Answer: (A)


Figure: The Solomon R. Guggenheim Museum in New York City was the first Guggenheim Museum established.

1. Ratio 'Golden Mean' is:
(A) 1: 2.216 (B) 1: 1.618 (C) 1: 1.50 (D) 1: 1.44 Answer: (B)

2. 'Mihrab' is found
(A) inside wall of a mausoleum (B) on the crown of minaret
(C) on the west wall of a mosque (D) in the stepped well of Gujarat

3. Which one falls under Indo-Sarasanic architecture?
(A) Qutab Minar **(B) Taj Mahal** (C) Sher Shah's tomb (D) Bahai Temple

4. Which of the following is not **a function of a good mulch:**
(A) Aid in water retention (B) Prevent soil temperature fluctuations
(C) Encourage weed growth (D) Improve landscape appearance

5. Byzantine architecture is famous for:
(A) Stone carving (B) Pointed arches (C) Fluted columns (D) **New type dome construction**

6. 'Gopuram' refers to
(A) Temple (B) **Gateway** **(C)** Village (D) Brick dome

7. Most efficient arch in transferring load:
(A) Semi circular (B) Flat (C) Pointed **(D) Catenary**

Notes: The catenary curve is interesting because there are many examples of it in the world around us. The best way to visualize a catenary curve is to imagine the shape of a hanging chain. (The word comes from the Latin word *catena* meaning "chain.") Catenaries are used in engineering and architecture, for example in the shape of hanging bridges, or when inverted, in the shape of some arches. One of the most impressive examples is the St. Louis Gateway Arch. Catenaries can also be found in nature, for example in the curve of a spider web.

At first glance, catenaries might look like parabolas, but they have a completely different formula. The formula gives a shape that has a special structural property when used as an arch. When the chain shape is inverted into an arch and divided into building blocks, the blocks can support each other by gravity alone. To fully understand how catenaries differ from parabolas and why chains take the shape of catenary curves, we need some calculus background which is out of syllabus.

Figure: St. Louis Gateway Arch *by Eero Saarinen*

period.

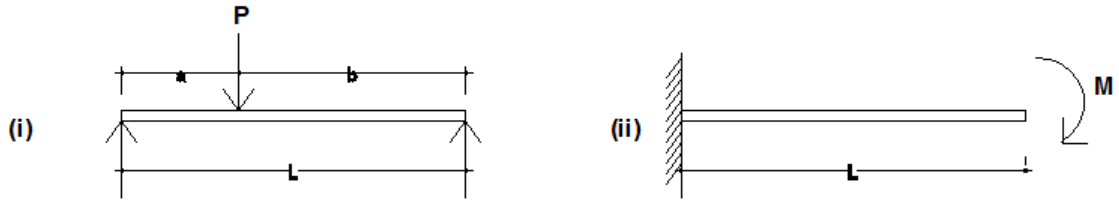
Q9.2 Define the term " Affordable cost" in housing.

Q9.3 Distinguish between 'home' and 'housing'.

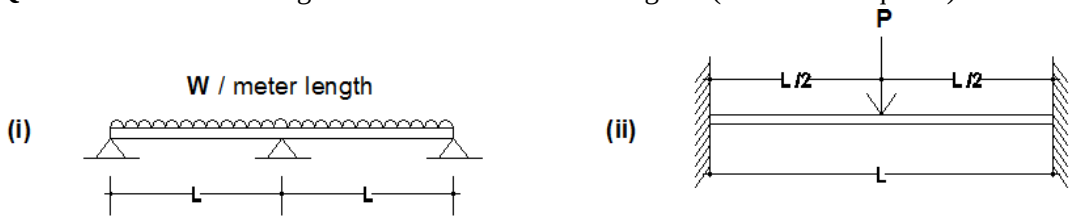
Q10.1 The residential landuse of an urban area accounts for 50 % of the developed land of the city. The vacant undeveloped land is about 30 % of the total urban area, which amounts to 2,400 hectare of land. Estimate the quantum of land put to residential uses and also the overall density of the urban area if the population is of 2,00,000 size.

Q10.2 Illustrate with sketches the 'Radbum principle' of housing layout.

Q.l1.1 Draw the bending moment and shear force diagram for the following:



Q11.2 Sketch the bending moment and shear force diagram (values not required) :



Q.12 Explain the following planting techniques:
12.1 Grafting
12.2 Layering
12.3 Cutting
12.4 Transplantation

Q.13 Draw the CPM network diagram with the activities as shown below:

S.N.	Activity	Preceding activity
1	A	-
2	B	A
3	C	A
4	D	C
5	E	B
6	F	E
7	G	D

Q14. Find the errors in the following FORTRAN program: (Out of syllabus now!)

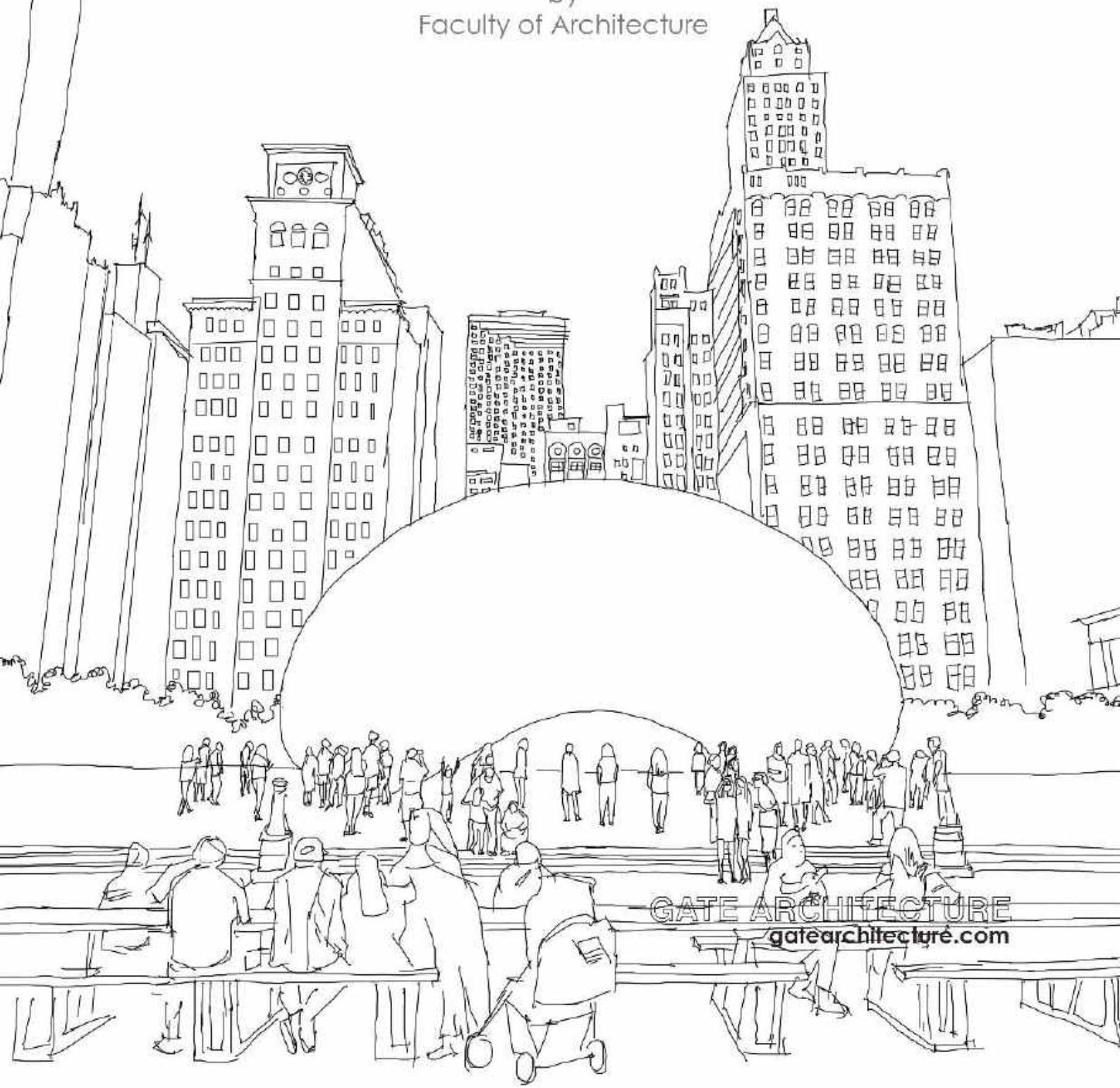
Q.15 Illustrate with sketches the optical correction in Architecture developed by the Greek.

END OF THEQUESTION PAPER

GATE NUMERICALS

28
YEARS
2018-1991

by
Faculty of Architecture



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Contents:

Notes: More references can be added or existing contents can be removed without prior information!

Preface

If you have already prepared for the exam, this book would be fruitful to you. This book is meant for last stage of preparation and add an edge to your preparation by reviewing sets of numerical questions asked in previous years. In past few years, the pattern of numerical question has changed. It is observed that upto 40% marks are of numerical questions. There would be approx. 7 numerical question of 1 or 2 marks of which no option would be given. You have to answer the question by using keypad displayed on the screen. (Use of keyboard is prohibited. Touching any key would lock your monitor screen and you may not able to answer any further question!)

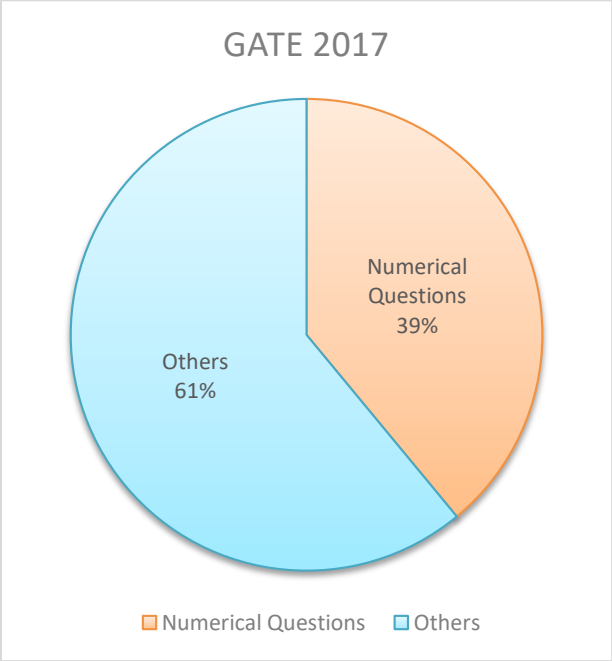
So, for such question pattern, you need through practice. We are hopeful that this book would meet the requirement.

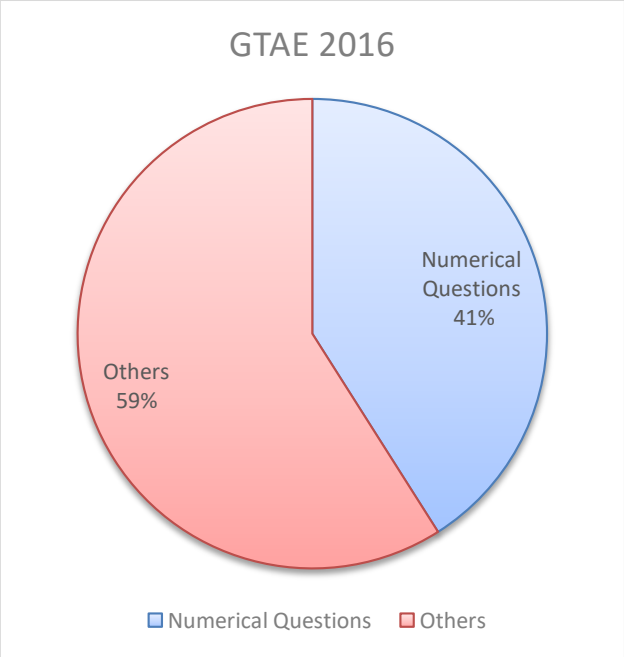
Answering an objective question has its own rule to follow when you have a doubt in choosing the right answer. For so, we have also attached expert opinion for handling objective question well.

In this book, we have also provided basics of theories which are very essential before you solve a question.

Last year trend (GATE 2016 AR):

No. of students applied (Approx.)	No. of students appeared (Approx.)	No. of students qualified	Highest marks obtained	Lowest mark obtained	Cut-off Mark	Average marks obtained	Standard deviation
6300	5900	1240	75.67	26.00	38.90	43.37	8.32





Most of the questions has been solved (95%). You are always welcome for your valuable suggestion and feedback about this book. If you find better contents or alternative solution, send us to gatearchitecture@gmail.com
We may add contents or solution by you in next reprint or edition!

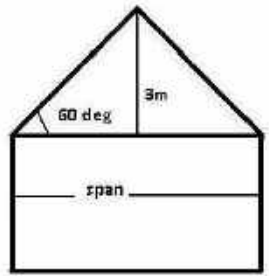
We wish you all the best for GATE 2018.

Tips & Tricks

Followings are tips & tricks for handling multiple choice questions suggested by experts from open source online resources. Please note that following insights are not only for Numerical Questions but also for all topics. Some of following are for paper bound exam (not online). You should skip those.

Tips for solving numerical problems:

- **Drawing the picture of the problem** is very important! The correct picture of a numerical problem is more than 80 % of success.

  Example (GATE 2013): If the slope of a hipped roof is 60º and height of the roof is 3 m, span of the room, in m, would be _____
  Solution: Span of the room = 2 * (3/tan60º) = 3.46 answer.

- **Having the same units for all variables in the problem**. You must ensure that you solve the problem in the same unit. For example, in a given question, force may be given 40 Newton (N) and length of the beam would be *l*= 50 centimetre. For easy and correct solution, you should change the length in meter (*l*= 0.5m). Tip: If the option is given as follows: (A) 50Pa (B) 5Pa (C) 10Pa (D) 100Pa. For this type of question, you must recheck your solution before you choose an answer.

- **Checking the dimensionality of analytical expressions**. To arrive at correct answer, you should always write the numerical value with it's unit.

  Example: Area of tense steel per meter width of a reinforced concrete slab is 335 sq mm. If 8 mm rods are used as reinforcement, then centre to centre spacing of the reinforcement in mm is

  Solution: Total area of steel is 335 sq mm. (which is spread in 1m of width)
  Area of 8 mm rod = Πr^2 = 3.14 x 4mm x 4mm = 50.24 sq mm { *8mm rod means it has diameter of 8mm*

  So, total no. of rods spread in 1m of width = $\frac{335 sqmm}{50.24 sqmm}$ = 335 /50.24 = 6.67 { *When' sqmm' is divided by 'sqmm', it becomes a dimensionless quantity. So, the result is a just number without any unit. Here, we want to calculate 'no. of rods', which does not have any dimension. So, our calculation is in right direction*.

  So, distance between two rods will be 1m/6.67 = 1000 mm/6.67 = 150 mm Answer { *Here, please note that we are dividing 1000mm /6.67 and not 1m/6.67. In the question "per meter" is mentioned. But for correct answer we need to convert 1m to 1000mm.*

Taking Multiple Choice Exams *(Source:1)*

Studying for a multiple choice exam requires a special method of preparation distinctly different from an essay exam. Multiple choice exams ask a student to recognize a correct answer among a set of options that include 3 wrong answers (called *distracters)*, rather than asking the student to produce a correct answer entirely from his/her own mind.

For many reasons, **students commonly consider multiple choice exams easier than essay exams**. Perhaps the most obvious reasons are that:

- The correct answer is *guaranteed* to be among the possible responses. A student can score points with a lucky guess.
- Many multiple choice exams tend to emphasize basic definitions or simple comparisons, rather than asking students to analyze new information or apply theories to new situations.
- Because multiple choice exams usually contain many more questions than essay exams, each question has a lower point value and thus offers less risk.

Important Topics

Acoustics

Sound is such a common part of everyday life that we rarely appreciate all of its functions. It provides enjoyable experiences such as listening to music or to the singing of birds.

Yet, too often in our modern society, sound annoys us. Many sounds are unpleasant or unwanted - these are called noise. However, the level of annoyance depends not only on the quality of the sound, but also our attitude towards it. For example the type of music enjoyed by some people could be regarded as noise by others, especially if it is loud.

The branch of science which deals with the planning of a building to provide the best quality audible sound to audience is termed as architectural acoustics or acoustics of the building.

Intensity Level (dB)

Bel & Decibell:

Whenever the intensity of sound increases by a factor of 10, the increase in the intensity is said to be 1 bel *(A unit named after Alexander Graham Bell, the inventor of telephone)*

Therefore dynamic range of audibility of the human ear is 12 bels or 120 dB. When the intensity increases by a factor of $10^{0.1}$, the increase in intensity is 0.1 bel or 1dB.

$\therefore$ in decibel

$$L = 10 \log_{10} \left(\frac{I}{I_0}\right)$$

I_0: base intensity (10^{-16} W/cm^2, hearing threshold)
I: intensity (W/cm^2)

For the intensity level change = 1 dB

$$1 = 10 \log_{10} \left(\frac{I}{I_0}\right)$$

$$\therefore \frac{I}{I_0} = 1.26 \quad \ldots(1.4)$$

If $I = I_0$,

$$L = 10 \log 1 = 0$$

This represents the threshold of audibility.
It means that intensity level alters by 1dB when intensity of sound changes by 26%

Intensity levels of different sounds

Sr. No.	Sound	Intensity level (in db)
(1)	Threshold of hearing	0
(2)	Rustle of leaves	10
(3)	Whisper	15 – 20
(4)	Normal conversation	60 – 65
(5)	Heavy traffic	70 – 80

Sr. No.	Sound	Intensity level (in db)
(6)	Thunder	100 – 110
(7)	Painful sound	130 and above

Phon : The intensity levels given in the above Table, refer to the loudness in decibels with the assumption that the threshold of audibility is the same irrespective of the pitch *(**Pitch is** a subjective sensation perceived when a tone of a given frequency is sounded. It enables us to classify a note as high or low and to distinguish a shrill sound from a flat sound of the same intensity on the same instrument.)* of the sound.

However, the sensitivity of the ear and the threshold audibility vary over wide ranges of frequency and intensity.

Hence the intensity level will be different at different frequencies even for the same value of I_0.

For measuring the intensity level a different unit called **phon** is used.

The measure of loudness in phons of any sound is equal to the intensity level in decibels of an equally loud pure tone of frequency 1000 Hz.

Hence Phon scale and decibel scale agree for a frequency of 1000 Hz but the two values differ at other frequencies.

Suppose the intensity level of a note of frequency 480 Hz is to be determined. A standard source of frequency 1000 Hz is sounded and the intensity of the standard source is adjusted so that it is equal to the loudness of the given note of frequency
480 Hz.

The intensity level of the standard source in decibels is numerically equal to the loudness of the given source in phons.

Example: Calculate the change in intensity level when the intensity of sound increases 100 times its original intensity.

Solution: Given,

Initial intensity = I_0
Final intensity = I

$$\frac{I}{I_0} = 100$$

Increase in intensity level = L

$$\therefore \quad L = 10 \log_{10} \left(\frac{I}{I_0}\right) \text{ (in dB)}$$

$$\therefore \quad \mathbf{L = 10 \log_{10} 100 = 20 \text{ dB Answer.}}$$

Example: Find the intensity level in phons if 3000 Hz with intensity level of 70 dB produces the same loudness as a standard source of frequency 1000 Hz at a intensity level 67 dB.

Solution : As the 3000 Hz source has the same loudness of standard source of 1000 Hz with 67 db, the intensity level of the note of frequency **3000 Hz is 67 phons. Answer.**

Example : If Sound Source IL_1=60 dB and Sound Source IL_2=50dB, what is the total sound intensity?

Solution: Step **1. Convert dB (intensity level) to intensity (W/cm^2)**

$IL_1=10 \log (I_1/I_0)$	$IL_2=10 \log (I_2/I_0)$
$60=10 \log(I_1/10^{-16})$	$50=10 \log(I_2/10^{-16})$
$6.0= \log(I_1/10^{-16})$	$5.0= \log(I_2/10^{-16})$
$10^6=I_1/10^{-16}$	$10^5=I_2/10^{-16}$
$I_1=10^{-10}$	$I_2=10^{-11}$

Step **2. Add intensity together**

$$I_1+I_2=1 \times 10^{-10} + 1 \times 10^{-11}$$
$$I_{TOT}=11 \times 10^{-11}\ W/cm^2$$

Step **3. Convert back to intensity level (dB)**

$$IL_{TOT}= 10 \text{ Log } (I_{TOT}/I_0)$$
$$IL_{TOT}=10 \text{ Log } (11 \times 10^{-11})/10^{-16}$$
$$IL_{TOT}=10 (\text{Log } 11 + \text{Log } 10^5)$$
$$IL_{TOT}=10 (1.04 + 5) = 60.4 \text{ dB}$$

The above calculation is time consuming & requires a lot of calculations. For approximate answer, follow the below thumb rule:

Question: Add two 60 dB sources
Solution: ΔdB=0 {difference in two dB sources is zero
Now, add 3 db to higher
IL=60+3=63 dB

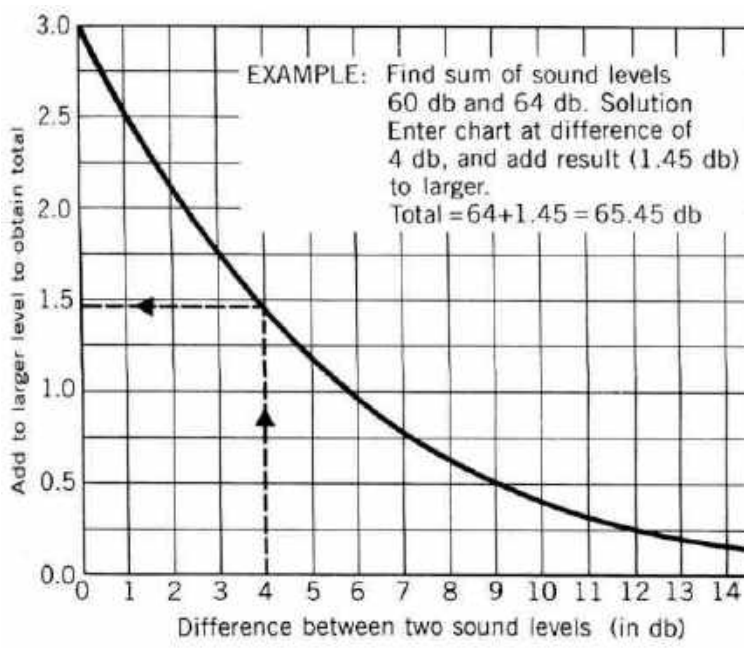


Figure: Remember this chart. It may save a lot of time to find the answer.

The Inverse Square Law

The inverse square law is one of the fundamental concepts used in the business of sound and acoustics. Fundamentally, this is what the inverse square law describes:
A. Every time the physical distance between you and the sound source doubles in distance, the sound will be 6 dB lower (softer).
B. The opposite holds true too. As the distance is cut in half, the sound will get louder by 6 dB
C. There are exceptions, but they are not critical to this discussion.

Here is a very basic example: Start with a sound source that is 86 dB when measured 3' in front of the source. Measure again at a distance of 6' and you will get a measurement of 80 dB, which is 6 dB lower. Move from 6' to 12' and the measurement will be 74 dB. Move from 12' to 24' and you get 68 dB. See the pattern? All this reverses when you move toward the source of the sound.
Critical Distance: In the glossary of audio terminology, "critical distance" defines the point at which direct sound and reverberant sound have the same SPL (Sound Pressure Level).

Reverberation and Echo

Reverberation and echo are often perceived as two separate acoustical phenomena, but in reality they are very much the same thing; just perceived differently because of the size and geometric characteristics of a room.

Reverberation (reverb) is highly-diffused sound energy that has reflected off of several surfaces or structural boundaries.
Echo is non-diffused, reflected sound energy, which exceeds our ear/brain "integration time".

For spoken word, the human ear/brain system perceives direct sound, and reflected sound that arrives within a range of about 30-60 milliseconds (ms), as being one in the same signal. The two discrete time arrivals are integrated or merged into one. The time arrival of the two is so close that we can't tell them apart.
A. 60ms represents the upper limits of this integration time, after which the late arriving sound is perceived as a discrete echo.
B. Based on many factors, the integration time for music can be slightly longer than 60 ms, but speech integration, and therefore intelligibility, are almost always the dominant concern.
1. A repetitive echo is sometimes called "flutter" echo because percussive sounds, like a hand clap, bounce rapidly between one or more sets of parallel surfaces, producing a "fluttery" sound.

Illumination

Terms

Visible Light Transmission (VLT)
The percentage of visible light that is transmitted through the glazing assembly. This is the essential characteristic for daylighting calculations. A perfectly clear window would have a VLT of 100 percent. Most practical assemblies for architectural use are between 35 and 80 percent.

Solar Heat Gain Coefficient (SHGC)
The percentage of total solar radiant energy that is transmitted through the assembly. This is the essential characteristic for solar gain calculations. For ordinary windows without special coatings, the SHGC and the VLT are the same and sometimes called the shading coefficient (SC). However, with modern coated windows, the SHGC is almost always lower than the VLT. Such window systems are generically referred to as *low-emissivity* or *lowE* and are used in most commercial construction.

Candela

The candela (unit cd) has its origin in the brightness of a "standard candle", but it has received a more precise definition in the International System of Units (SI) — and at that time the unit was also renamed from "candle" to "candela".

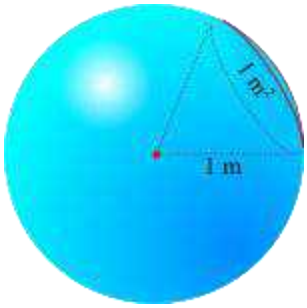


Figure: **Creation of a solid angle.**

The candela measures the amount of light emitted in the range of a (three-dimensional) angular span. Since the luminous intensity is described in terms of an angle, the distance at which you measure this intensity is irrelevant. For ease of illustration, in the picture at the right the three dimensions have been flattened to two. In this picture, screen B would catch exactly the same amount of light rays (emitted from the light source) as screen A —provided that screen A were removed to not obscure screen B. This is because screen B covers the same angle as screen A.

Figure: **The candela measures the amount of light emitted in the range of a (three-dimensional) angular span. The luminous**

The angular span for candela is expressed in steradian, a measure without unit (like radian for angles in a two-dimensional space). One steradian on a sphere with a radius of one metre gives a surface of one m^2. A full sphere measures 4π steradians.

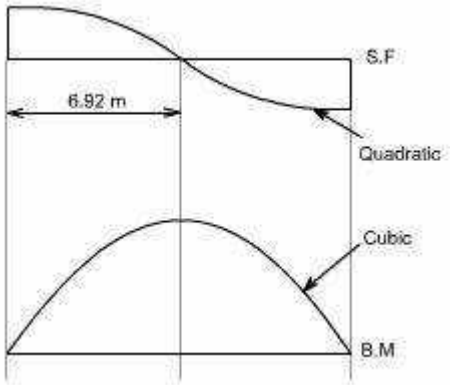
Lumen

If you look at LEDs, especially high-brightness LEDs, you may notice that the LEDs with a high luminous intensity (in candela or milli-candela, mcd) typically have a narrow apex angle. Similarly, LEDs with a wide apex angle typically have a relatively low luminous intensity. The same is true for halogen spots with reflector: those with a narrow-beam reflector have a higher rating in candela than the "floodlight" spots of the same power.

The cause for this relation is the total energy produced by the LED. LEDs of a specific class (for example, "high flux") all produce roughly the same amount of luminous energy. However, when a LED emits its total energy in a beam with a narrow angle, the intensity will be greater (in the direction of that angle) than when *the same* energy had been emitted over a wide angle.

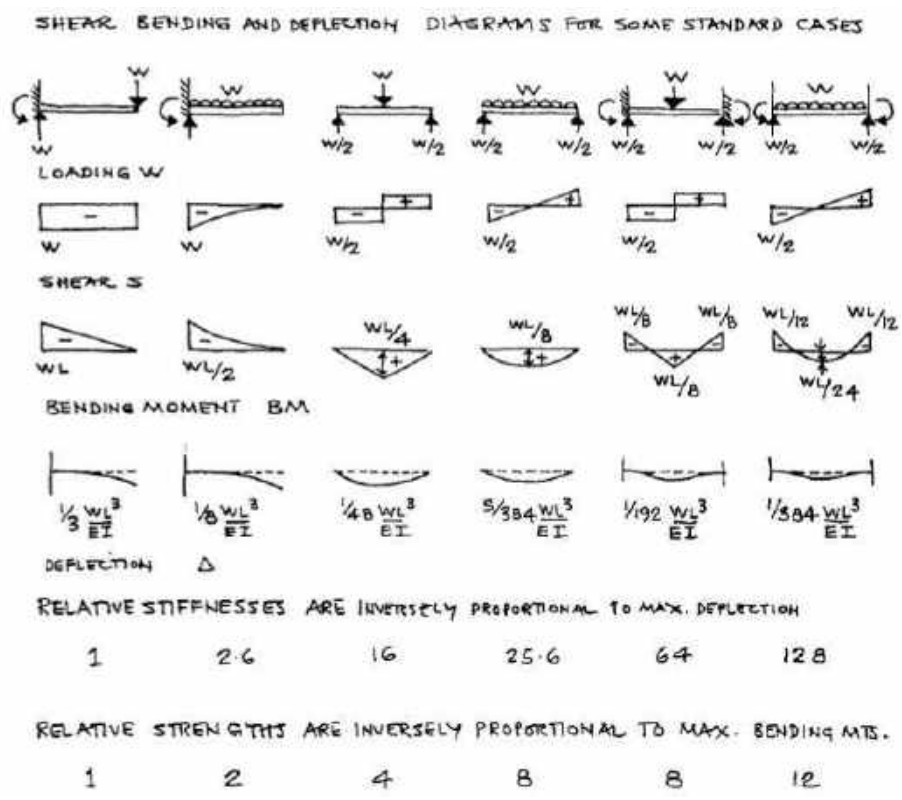
The lumen (unit lm) gives the total luminous flux of a light source by multiplying the intensity (in candela) by the angular span over which the light is emitted. With the symbol Φv for lumen, Iv for candela and Ω for the angular span in steradian, the relation is:

$\Phi v = Iv \cdot \Omega$



Common Relationships

Load	0	Constant	Linear
Shear	Constant	Linear	Parabolic
Moment	Linear	Parabolic	Cubic



CPM/PERT

Introduction

Basically, CPM (Critical Path Method) and PERT (Programme Evaluation Review Technique) are project management techniques, which have been created out of the need of Western industrial and military establishments to plan, schedule and control complex projects.

Brief History of CPM/PERT

CPM/PERT or Network Analysis as the technique is sometimes called, developed along two parallel streams, one industrial and the other military.

CPM was the discovery of M.R.Walker of E.I.Du Pont de Nemours & Co. and J.E.Kelly of Remington Rand, circa 1957. The computation was designed for the UNIVAC-I computer. The first test was made in 1958, when CPM was applied to the construction of a new chemical plant. In March 1959, the method was applied to a maintenance shut-down at the Du Pont works in Louisville, Kentucky. Unproductive time was reduced from 125 to 93 hours.

PERT was devised in 1958 for the POLARIS missile program by the Program Evaluation Branch of the Special Projects office of the U.S.Navy, helped by the Lockheed Missile Systems division and the Consultant firm of Booz-Allen & Hamilton. The calculations were so arranged so that they could be carried out on the IBM Naval Ordinance Research Computer (NORC) at Dahlgren, Virginia.

The Framework for PERT and CPM

Essentially, there are six steps which are common to both the techniques. The procedure is listed below:

1. Define the Project and all of it's significant activities or tasks. The Project (made up of several tasks) should have only a single start activity and a single finish activity.
2. Develop the relationships among the activities. Decide which activities must precede and which must follow others.
3. Draw the "Network" connecting all the activities. Each Activity should have unique event numbers. Dummy arrows are used where required to avoid giving the same numbering to two activities.
4. Assign time and/or cost estimates to each activity
5. Compute the longest time path through the network. This is called the critical path.
6. Use the Network to help plan, schedule, monitor and control the project.

The Key Concept used by CPM/PERT is that a small set of activities, which make up the longest path through the activity network control the entire project. If these "critical" activities could be identified and assigned to responsible persons, management resources could be optimally used by concentrating on the few activities which determine the fate of the entire project.

Non-critical activities can be replanned, rescheduled and resources for them can be reallocated flexibly, without affecting the whole project.

Five useful questions to ask when preparing an activity network are:

- Is this a Start Activity?
- Is this a Finish Activity?
- What Activity Precedes this?
- What Activity Follows this?
- What Activity is Concurrent with this?

Some activities are serially linked. The second activity can begin only after the first activity is completed. In certain cases, the activities are concurrent, because they are independent of each other and can start simultaneously. This is especially the case in organisations which have supervisory resources so that work can be delegated to various departments which will be responsible for the activities and their completion as planned.

When work is delegated like this, the need for constant feedback and co-ordination becomes an important senior management pre-occupation.

Heat

Understanding fundamental heat flows from conduction, convection, and radiation is key to creating energy efficient buildings. Moisture flows are also important because moisture holds energy as "latent heat."

Sensible vs. Latent Heat Flows

There are of two forms of heat flows: **sensible heat** and **latent heat**. Sensible heat flow results in a change in temperature. Latent heat flow results in a change in moisture content (often humidity of the air). Total heat flow is the sum of sensible and latent flows. Human comfort depends on providing acceptable levels of both temperature (sensible heat) and humidity (latent heat).

Sensible heat: The heat associated with change in temperature of a substance/

Latent heat: The release or storage of heat associated with change in phase of a substance, without a change in the substance's temperature. In building design, this is often heat required to add/remove moisture content (humidity) in the air. Hot dry air is actually less uncomfortable than hot humid air, because moisture holds energy as latent heat.

Whenever an object is at a temperature different from its surroundings, heat flows from hot to cold. Likewise, moisture flows from areas of greater concentration to areas of lower concentration.

Conduction, Convection, and Radiation

Buildings lose sensible heat to the environment (or gain sensible heat from it) in three principal ways:

1) Conduction: The transfer of heat between substances which are in direct contact with each other. Conduction occurs when heat flows through a solid.

2) Convection: The movement of gasses and liquids caused by heat transfer. As a gas or liquid is heated, it warms, expands and rises because it is less dense resulting in natural convection.

3) Radiation: When electromagnetic waves travel through space, it is called radiation. When these waves (from the sun, for example) hit an object, they transfer their heat to that object.

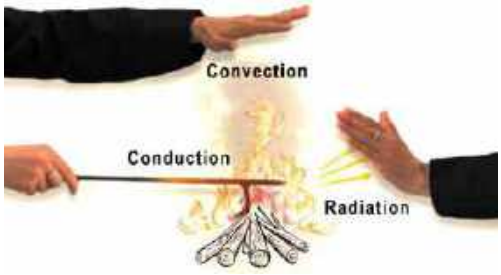


Figure: The way that you experience the heat from a fire is a good example of conduction, convection, and radiation.Heat conducts through materials placed in the fire, like a metal poker. You can stop the conduction to your hand by using an insulating pad. Heat (and smoke) travels away from the fire through the air. The direction it travels depends on the wind and pressure differences (convection).Heat radiates from the fire to where you are. You can avoid the radiation by putting a material between you and the fire, or stepping away.

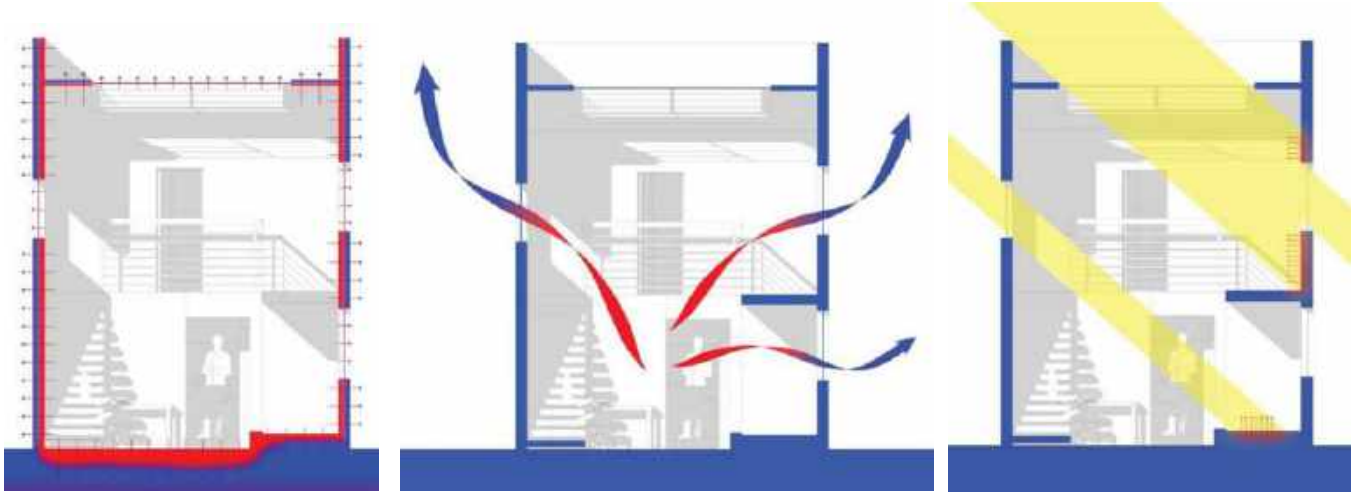


Figure: Conduction, convection, and radiation heat transfer take place almost everywhere we look. In a building envelope, conduction primarily takes place through opaque envelope assemblies, convection is usually the result of wind or pressure-driven air movement, and radiant heat transfer is primarily from the sun through fenestrations. Building HVAC systems are typically designed to provide comfort using convective or radiant modes of heat transfer.

GATE QUESTION PAPERS

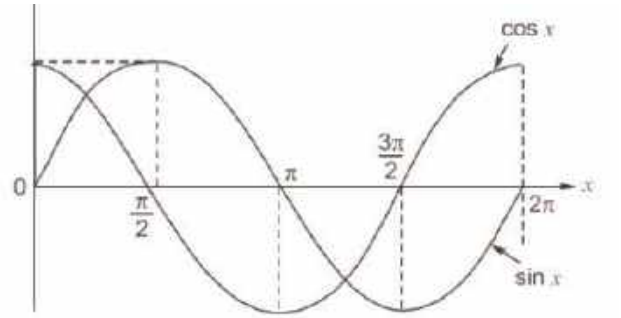
GATE 2018

Q.1 For $0 \le x \le 2\pi$, sin x and cos x are both decreasing functions in the interval.

(A) $(0, \pi/2)$ (B) $(\pi/2 , \pi)$ (C) $(\pi, 3\pi/2)$ (D) $(3\pi/2 , 2\pi)$

Answer: B

From the curve it is clear that sin$x$ and cos$x$ both are decreasing in the interval $(\pi/2 , \pi)$



How to plot the graph? To plot this graph you need to know the value of sinθ & cosθ for the values of 0°, 30°, 45°, 60° and 90°. For that you do not have to remember the values. Open the 'Scientific Calculator' by clicking on the icon of calculator on the question screen during GATE exam.

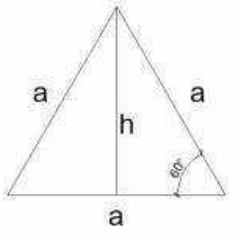
Figure: Visit the official GATE website and appear for a Mock Test to be familiar with function of the 'Scientific Calculator' and UI.

Q.2 The area of an equilateral triangle is √3. What is the perimeter of the triangle?

(A) 2 (B) 4 (C) 6 (D) 8

Answer: C

Area of triangle = 1/2 (Base*Height) = 1/2 (a*h)
= 1/2 (a*a *sin60°*) = 1/2 ($a^2\sqrt{3}/2$) = √3 (given)



So, perimeter of triangle = 3*a = 3*2 = **6 Answer**

Q.3 Arrange the following three-dimensional objects in the descending order of their volumes:

(i) A cuboid with dimensions 10 cm, 8 cm and 6 cm
(ii) A cube of side 8 cm
(iii) A cylinder with base radius 7 cm and height 7 cm
(iv) A sphere of radius 7 cm

(A) (i), (ii), (iii), (iv)
(B) (ii), (i), (iv), (iii)
(C) (iii), (ii), (i), (iv)
(D) (iv), (iii), (ii), (i)

Answer (D)

Volume of cuboid = l*b*h = 10*8*6 = 480
Volume of cube = $l^3 = 8^3 = 512$
Volume of cylinder = (perimeter)*(height) = $2\pi r*h = 2\pi 7*7 = 615$
Volume of sphere = $4/3* \pi r^3 = 1432$

Q.4 An automobile travels from city A to city B and returns to city A by the same route. The speed of the vehicle during the onward and return journeys were constant at 60 km/h and 90 km/h, respectively. What is the average speed in km/h for the entire journey?

(A) 72 (B) 73 (C) 74 (D) 75 Answer (A)

Solution, Let, the distance between city A & B be ***x***
So, total distance (onward & return journey) = x + x = 2x
For onward journey, speed S1 = 60km/h and time taken = x/60
For return journey, speed S2 = 90km/h and time taken = x/90
Therefore, Average Speed = Total Distance/Total Time = (x+x)/[x/60+x/90] = 2*90*2/5 = **72 km/h**

Q.5 A set of 4 parallel lines intersect with another set of 5 parallel lines. How many parallelograms are formed?

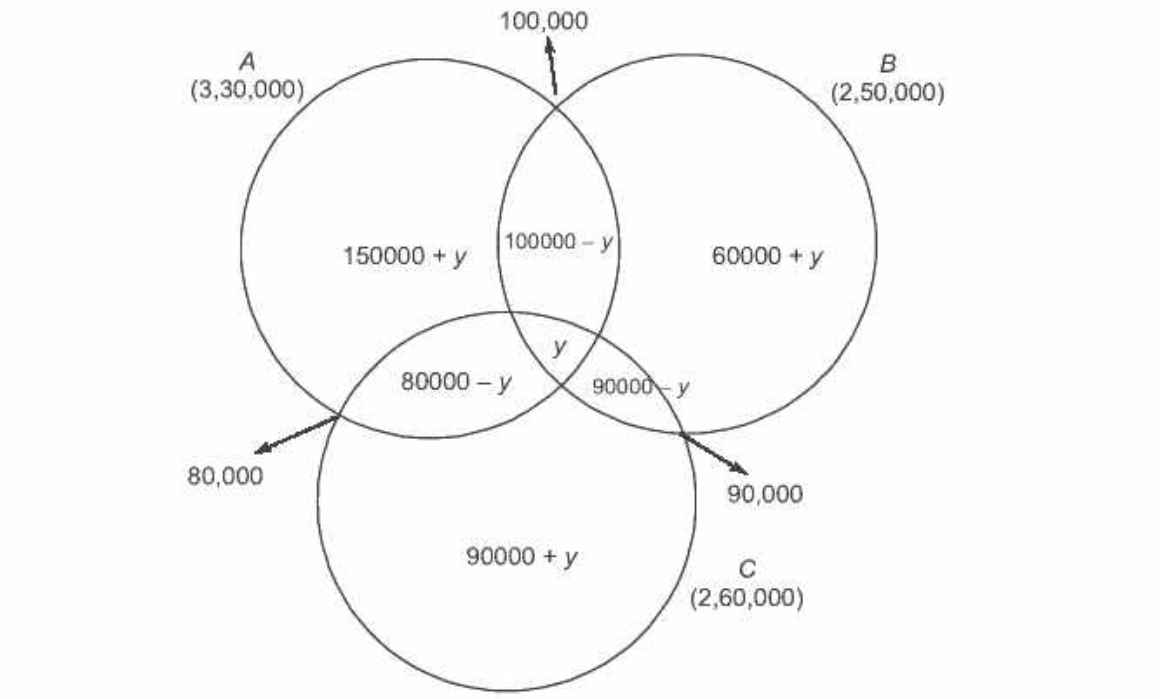
(A) 20 (B) 48 (C) 60 (D) 72 Answer (C)

To make a parallelogram we need two parallel lines in one direction and other two parallel lines in other direction. It is given that we have 4 parallel lines in one direction and 5 parallel lines in other direction. Now, we have to choose any 2 parallel lines from 4 parallel lines and other 2 lines from the other 5 parallel lines. In mathematics, number of

parallelogram = ${}^4C_2 \times {}^5C_2$ = 6*10 = **60 Answer**

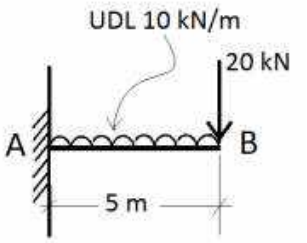
Q.6 To pass a test, a candidate needs to answer at least 2 out of 3 questions correctly. A total of 6,30,000 candidates appeared for the test. Question A was correctly answered by 3,30,000 candidates. Question B was answered correctly by 2,50,000 candidates. Question C was answered correctly by 2,60,000 candidates. Both questions A and B were answered correctly by 1,00,000 candidates. Both questions B and C were answered correctly by 90,000 candidates. Both questions A and C were answered correctly by 80,000 candidates. If the number of students answering all questions correctly is the same as the number answering none, how many candidates failed to clear the test?

(A) 30,000 (B) 2,70,000 (C) 3,90,000 (D) 4,20,000 Answer (D)



6,30,000 = 2y + 1,50,000 + 1,00,000 + 80,000 + 60,000 + 90,000 + 90,000
⇨ 6,30,000 – 5,70,000 = 2y
⇨ y = 30,000 Answer
Student who failed to clear the test = 1,50,000 + 60,000 + 90,000 + 4y = 3,00,000 + 4*30,000 = **4,20,000 Answer**

Q.23 In the Figure, the negative bending moment at point A of the cantilever is _____ kNm.



Solution: The question will be very easy if divide the question in 2 parts. In part one, find the moment due to UDL of 10 kN/m and in second part, fine the moment due to point load of 10kN. And then add both.

Moment = $WL^2/2 + WL$
= (10kN/m*5m*5m)/2 + 20kN*5m = 125+100 = **225Nm Answer** (Official GATE answer varied from 224 to 226)
Refer Question No. 3 of GATE 2002 in this book as a reference.

Q.23 The water consumption of a high rise apartment building with 60 dwelling units having an average household size of 5 persons is 135 lpcd. Assuming 80% of the total use is met with recycled water supply, the daily domestic demand for the building is _____litres.

20% of (60*5*135) = **8100 litres Answer**

Q.24 In India, for 1.0 cum of M-20 grade concrete, the number of cement bags required is _____(up to two decimal places).

As we know that during concreting when we place wet concrete , it gets harden after certain standard time(30 mins IST & 10hrs FST), considering same it had be decided to take a factor of safety ranging from 1.54 to 1.57 to counter that shrinkage. i.e volume of dry Concrete = 1.54 to 1.57 times volume of wet concrete.

Now calculations is as follows for 1cum of Concrete work
Ratio Sum = 1+1.5+3=5.5
Shrinkage or safety Factor =1.57 (you can take 1.54 also)
So Total volume of wet concrete required is 1.57cum
Volume of broken stone required = (3/5.5) x 1.57 = 0.856 m^3
Volume of sand required = (1.5/5.5) x 1.57 = 0.471 m^3
Volume of cement = (1/5.5) x 1.57 = 0.285 m^3 = 0.285 x1440 = 411 kg
For 1m^3 of M20 (1:1.5:3)
Broken stone = 0.856 m^3
Sand = 0.472 m3
Cement = 8.22 bag. (Official GATE answer varied from 5 to 9)

https://www.researchgate.net/post/how_we_calculate_of_Sand_cement_and_aggregate_of_M20_ratio_or_other_ratio

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Q.25 The sound power level of an outdoor non-directional point source is 90 dB. Considering an atmospheric impedance of 400 rayls, the sound pressure level at 10 m distance from the source is _____dB.

Solution:

$$L_p = L_W - \left|10 \cdot \log\left(\frac{Q}{4\pi \cdot r^2}\right)\right|$$

Where,
L_W = Sound power level (SWL) = 90dB
Q = Directivity factor = 1 (for 400 rayls)
r = Distance to sound source = 10 meters
L_p = Sound pressure level (SPL) = **59 dBAnswer** (Official GATE answer varied from 58 to 59)
http://www.sengpielaudio.com/calculator-soundpower.htm

GATE 2017

Q.1 The unit for measuring sound absorption in a room is

(A) Sabin (B) Phon (C) Decibel (3) Hertz

Notes: The term "**sound absorption**" very common to acoustics and question is asked very frequently in GATE for calculating Reverberation time = 0.016*(V/a), where a = **sound absorption** coefficient in Sabin.

The unit is named in honor of Wallace Clement Sabine. So, Sabin is a unit of Sound Absorption of a surface. A square metre of 100% absorbing material has a value of 1 metric sabin. An example of this would be a 1 m² open window. One square foot of 100% absorbing material has a value of 1 imperial sabin.

Decibels, Phons, and Sones:

The rate at which sound energy reaches a given cross-sectional area is known as the sound intensity. It is common to express the sound intensity using a logarithmic scale known as the **decibel** scale.

Sound loudness varies from person to person. Furthermore, sounds with equal intensities but different frequencies are perceived by the same person to have unequal loudness. For instance, a 60 dB sound with a frequency of 1000 Hz sounds louder than a 60 dB sound with a frequency of 500 Hz. The unit **phon** is used to indicate an individual's perception of loudness. By definition, 1 phon is equivalent to 1 deciBel at 1000 Hz (1 kHz).

The sone scale is a third scale associated with the loudness of a sound. The sone scale is based on the observation that a 10 phon increase in a sound level is most often perceived as a doubling of loudness. According to the sone scale, a 1 sone sound is defined as a sound whose loudness is equal to 40 phons.

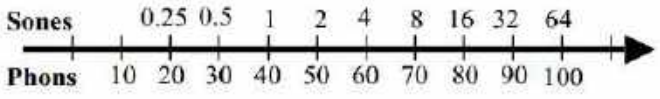


Figure: Relationship between Phon & Sone. Thumb rule.

Answer: (A) Sabin

Q.2 A drainage basin of 180 hectares comprises 40% wooded area, 45% grassed area and 15% paved area. Runoff coefficients for wooded, grassed and paved areas are 0.01, 0.2 and 0.95 respectively. The composite runoff coefficient for the drainage basin is

Solution: C = [(0.01x 40% of 180)+ (0.2 x 45% of 180) + (0.95 x 15% of 180)] / 180 = (0.72 + 16.2 + 25.65)/180 = 0.236 = 0.24

Composite runoff coefficient, $C = (A_1.C_1 + A_2.C_2 + \ldots) / (A_1 + A_2 + \ldots)$ **Answer: 0.24**

Q3. He was one of my best _____ and I felt his loss_____

(A) friend, keenly (B) friends, keen (C) friend, keener (D) friends, keenly

Solution: In the first blank, the word 'friends' is apt. The author talks about him being one of the many, he has. In the second blank, the word 'keen', which means 'sharp, piercing, or biting' can be used to describe an emotional loss. The word 'keen' in this sentence is modifying 'felt', which is a verb. Hence it must be used in its adverbial form. Hence, 'keenly' is apt.

Hence, the correct option is (D).

Q4. As the two speakers became increasingly agitated, the debate became

(A) lukewarm (B) poetic (C) forgiving (D**) heated**

Solution: The word 'agitated' shows that the two speakers became disturbed and excited- leading to a heated arguments. 'Heated' means to be excited or to be aroused to a high degree of passion or feeling. The rest of the options are inapt.

Hence, the correct option is (D).

Q9. One litre of acrylic paint can cover 16 sqm of wall area for the first coat and 24 sqm for the second coat. The walls of a lecture hall measuring 12m × 8m × 4m (L × B × H) need to be painted with two coats of this paint. The hall has total glazed fenestration area of 12 sqm. The number of 4 litre paint containers required will be _____ (2 marks)

Solution: Area to be painted = Area of walls – Area of window = 160 – 12 = 148 sqm

Paint required for 1st coat = 148/16 = 9.25 litres……..(A)
Paint required for 2nd coat = 148/24 = 6.17 litres…….....(B)

Total paint = 9.25 + 6.17 = 15.42 litres = 16 litres

So, The number of **4-litre paint containers** required will be 16/4 = 4 containers

Also, the answer provided by the official GATE is 4 but we do not agree with this answer because *Paint required for 1st coat = 9.25 litres* (A) seems incorrect as 9.25 litres of paint can do 148 sqm of first coat and *also* 9.25*24=222 sqm of second coat. Similarly *Paint required for 2nd coat = 6.17 litres* (B) may be incorrect as 6.17 litres of paint can do148 sqm of 2nd coat and *at the same time* it can also do 6.17*16= 98.72 sqm of 1st coat!

One more argument:

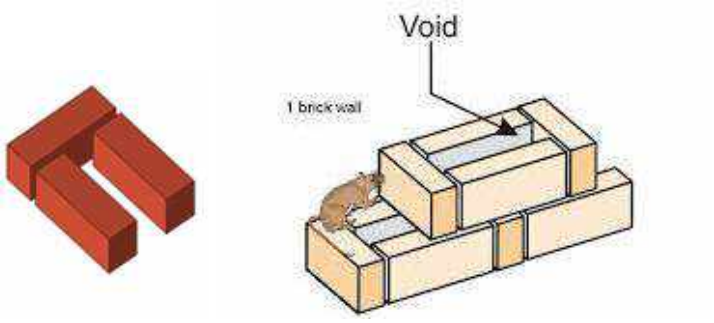
Let the answer be 4.
It means, it will require 4x4 = 16 liters of paint.
Now, as per question:
1 liter can paint 16 sqm of first coat + 24 sqm of second coat.
For, 16 liters of paint, we can paint 16x16 =256 sqm of area for the first coat & 16x24=384 sqm of area for second coat.
But we need only 148 sqm for first coat & 148 sqm for second coat.
So the answer 4 might not be correct
In the same way, we can crosscheck if the answer is 3.

Now, solve the following question:

One litre of acrylic paint can cover 16 sqm of wall area for the first coat 'OR' 24 sqm for the second coat. The walls of a lecture hall measuring 12m × 8m × 4m (L × B × H) need to be painted with two coats of this paint. The hall has total glazed fenestration area of 12 sqm. The number of 4 litre paint containers required will be _____ ?

Q10. The estimated number of bricks (unit size: 250 mm × 125 mm × 75 mm) for laying one course of a 250 mm thick brick wall using rat-trap bond for a running length of 3.9 meter will be _____ (2 marks)

Answer: 36



One set of rat-trap contains 3 bricks as shown whose overall length is 75 + 250 = 325mm.
So, no. of brick set = 3900mm/325mm = 12 brick set.

So, no of bricks = 12*3 = 36 bricks

Q11. In 2001, the population and work force participation rate of a town were 30,000 and 30 percent respectively. The work force participation rate in the year 2011 increased to 34 percent. If the decadal population growth rate was 6 percent, the increase in the number of working people in the town in 2011 was _____ (2 marks)

Solution: Working population in 2001 = 9000
In 2011, total population = 30,000 + 6% of 30,000 = 31,800
Now, 34% of 31,800 is the work force = 10812
So, increase in work force = 10812 – 9000 = 1812 Answer

Q12. In a 20 storey building with 3m floor to floor height, a passenger lift is hoisted by a steel rope. Weight of the lift owned is 750 kg and ultimate load the steel rope can carry is 39,000 kg. Assuming a factor of safety of 20 for the steel rope and an average passenger weight of 75 kg, the passenger capacity of the lift is _____

Solution: Usable strength of steel rope = 39000/20 = 1950 kg
Strength of steel rope considering liftcar weight = 1950 – 750 = 1200kg
Capacity of lift = 1200/75 = 16 person Answer

Q13. A room is mechanically ventilated through four air-conditioning ducts. The opening area of each duct is 0.35 sqm. The air velocity in the duct is 0.5 m/s. The temperature difference between the ambient air and supply air is 10 °C. Volumetric specific heat of air is 1250 J/m3 °C. Assuming one Ton of refrigeration (TR) equals 3.5 kW, the cooling load of the room in TR will be_____ (2 marks)

Solution: Total area of the duct = 4 x 0.35 = 1.4 sqm
Total air volume in the room collected in 1 hr (3600 sec) = 1.4 x 0.5 x 3600 = 2520 cum
Total energy required = msΔt = 2520 x 1250 x 10 = 31500000 Joule
Load in TR = (31500000/3.5KW)/3600 = (31500000/3500)/3600 = 2.5 Answer

Q14. Find the reverberation time of room 4m x 3m x 3m (LBH) with the help of following data.

	Wall		Ceiling		Floor
Percentage area	30	70	40	60	100
Absorption coefficient	0.4	0.1	0.6	0.1	0.1

Solution: t = 0.16* [(V/A)] = 0.16 [(4x3x3)/12.78] = 0.45 Sec
Calculation of 'A'
Wall area = perimeter of wall x height = [2(4+3)] x [3] = 42 sqm = P
Ceiling area = 4x3 = 12 sqm = Q
Floor area = 4x3 = 12 sqm = R
So, A = P[(0.4 x 30%) + (0.1 x 70%)] + Q[(0.6 x 40%) + (0.1 x 60%)] + R (0.1 x 100%)
= P[(0.4 x 0.3) + (0.1 x 0.7)] + Q[(0.6 x 0.4) + (0.1 x 0.6)] + R (0.1 x 1)
= 42[(0.4 x 0.3) + (0.1 x 0.7)] + 12[(0.6 x 0.4) + (0.1 x 0.6)] + 12 (0.1 x 1)
= 42(0.12 + 0.07) + 12(0.24 + 0.06) + 12 x 0.1
= 42 x 0.19 + 12 x 0.3 + 1.2
= 7.98 + 3.6 + 1.2
= 12.78 Answer: 0.45

Q15. A four-storey building with equal areas in each floor is required to be designed on a plot with FAR of 2.0. If the FAR is increased to 2.2, the percentage increase in ground coverage utilizing full FAR in both cases will be _____ (2 marks)

GATE 2010

Q.1 When shear stress exceeds the permissible limit in a RCC slab, then this problem is solved by

(A) Increasing the slab depth
(B) Providing shear reinforcement
(C) Using high strength steel
(D)Using thinner bars but more in number

Notes: Increasing the slab depth
Stress = Force/Area
So, If area is increased, stress will be decreased.
Area can be increased by increasing its depth.

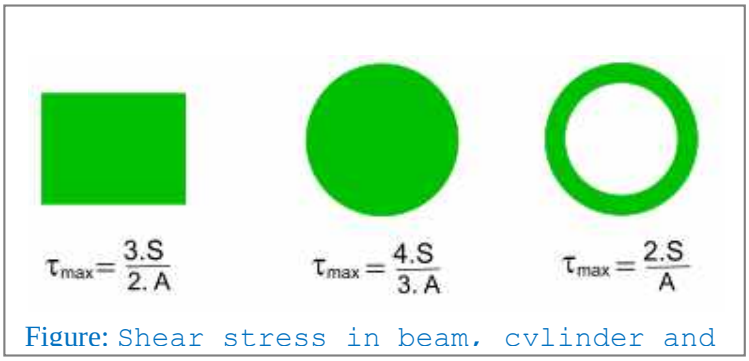


Figure: Shear stress in beam, cylinder and

A= Section area (m^2)
S = Shear Force on Section (N)

Answer: (A)

Q.2 Considering the total heat loss from all fluorescent lamps to be 79%,the Heating load (Btu/ hr) due to office illumination with 48 ceiling mounted luminaries, each containing four 40 W fluorescent lamps and flat surface diffusers will be

(A) 10000 Btu/ hr (B) 15000 Btu / hr (C) 17500 Btu/ hr (D) 21000 Btu / hr

Notes: The **British thermal unit** (symbol **Btu** or sometimes **BTU**) is a traditional unit of energy equal to about 1055 joules.

Total heat generated by the Lamp = 0.79X48X40X4= 6067.2 Joule/sec
=0.79X48X40X4X3600= 218411920 joule/hr
=218411920/1055= 20703.24 Btu/hr
= 21000 Btu/hr

Answer: (B)

Q.3 A square pin jointed truss is subjected to a load P, acting in the direction of member US, at joint U, The force in member UR is

(A) 1.414 P (B) 1.000 P (C) 0.707P (D) 0.000 P

Notes: PxCos45=0.707P

Answer: (C)

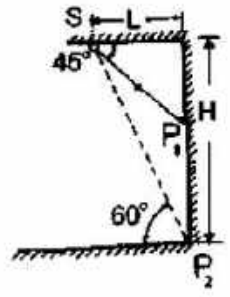
Q.4 If the area of a plot is 1000 sq.m., area of its adjoining roads is 500 sq.m., maximum permissible FAR is 150 and maximum permissible Ground Coverage is 50%, then utilizing fullest ground coverage and assuming floors of equal area, the number of storeys that can be built on the plot is

(A) 6 (B) 4 (C) 3 (D) 2

Answer: (C) 3

Solution: Plot area = 1000 sq.m.
Total floor area = 1.5*1000 = 1500 sq.m.
Ground coverage = 50% of plot area = 0.5*1000 = 500 sq.m.
So, no. of floors = Total floor area/Ground coverage = 1500 sq.m. / 500 sq.m = 3 Answer

Q.5 In a display window of height H = 8.66 m, of a retail store, a luminaire of intensity L is mounted at a distance = 5 m away from the rear. Its light beam is cast at an angle of 45° from the ceiling, as shown in the figure alongside.



The ratio of illumination at points P_1 and P_2

(A) 1:√3 (B) √3:2 (C) √2:1 (D) 1:2

Solution: Let illumination at point S, P_1 and P_2 be I , I_1 and I_2 respectively.

We have to calculate the value of I_1 / I_2. Obviously illumination at point P_1 will greater than illumination at point P_2 because P_1 is nearer to light source than P_2.

So, Value of I_1 / I_2 will be always greater than 1. Therefore, option (A) and (D) is incorrect. Now we have to choose the answer from option (B) and (C).

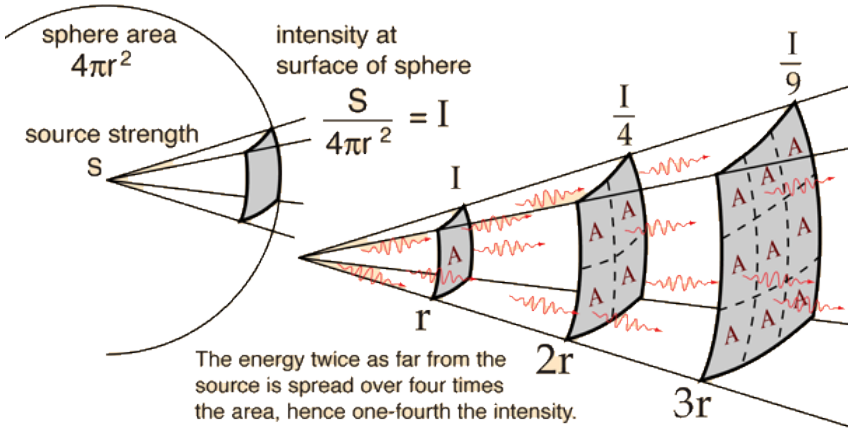
Now, with simple calculation, you can find the distance of P1 from light source as 5√2m and distance of P2 from light source as 10m.

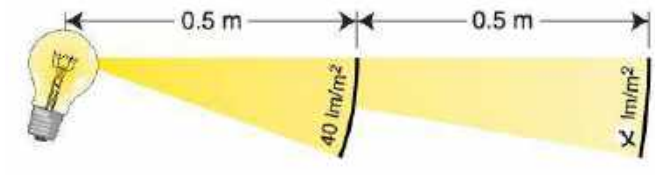
So, $I_1 = [I / (5\sqrt{2})^2]*\text{Cos}45° = [I / (5\sqrt{2})^2]*1/\sqrt{2} = I / 50\sqrt{2}$
And $I_2 = [I / (10)^2]*\text{Cos}60° = [I / (10)^2]*1/2 = I / 200$
Therefore, $I_1 / I_2 = (I / 50\sqrt{2}) / (I / 200) = 200 / 50\sqrt{2} = 4 / \sqrt{2} = 2\sqrt{2}$ Answer Answer : (None)
(Even if we ignore *Cosine Law of Illuminance* for a moment, the answer does not match to the options)

Notes: **The Inverse Square Law of Illuminance**

This law states that the Illuminance (E) at any point is inversely proportional to the square of the distance between the source and plane.

$$E = \frac{I}{d^2}$$



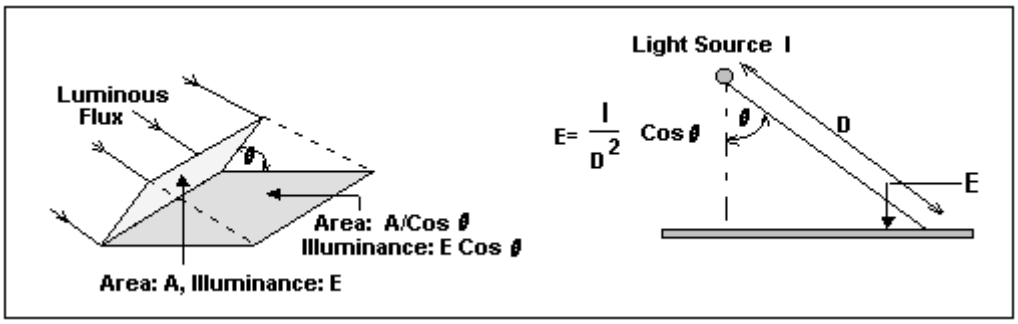


[Can you find the value of *x* ?]

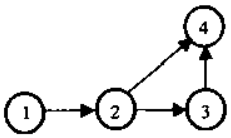
The Cosine Law of Illuminance

The law states that Illuminance at a point on a plane is proportional to the cosine of the angle of light incident (the angle between the direction of the incident light and the normal to the plane). It is given by the following formula:

$$E = \frac{I_\theta}{d^2}\cos\theta$$



Q.6 Following figure shows network for a particular project consisting of four activities.



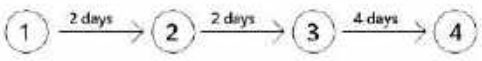
Normal duration and crash time for each activity are given below.

Activity	Normal duration (in days)	Crash time (in days)
1 - 2	3	2
2 - 3	4	2
2 - 4	5	4
3 - 4	7	5

The minimum time required for completion of project is

(A) 9 days (B) 13 days (C) 14 days (D) 19 days

Solution: Minimum time will be calculated by the crash time of activities with longest path duration.

Here, we have total 9 days. 

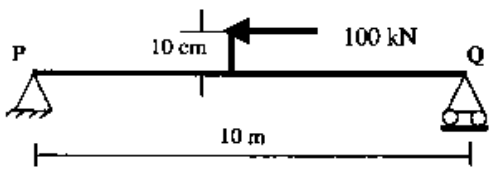
Notes: **Normal time (t_n):** Normal time is the standard time that an estimator would usually allow for an activity.
Crash time (t_c): Crash time is the minimum possible time in which an activity can be completed, by employing extra resources. Crash time is that time, beyond which the activity cannot be shortened by any amount of increase in resources.
Normal cost (C_n): This is direct cost required to complete the activity in normal time duration.
Crash cost (C_c): This is the direct cost corresponding to the completion of the activity within crash time.

Answer: (A) 9 days

Common Data Questions

Common Data for Questions 7 and 8:

A simply supported beam PQ is subjected to a load of 100 kN through a rigid link at the centre of the beam as shown in the figure below



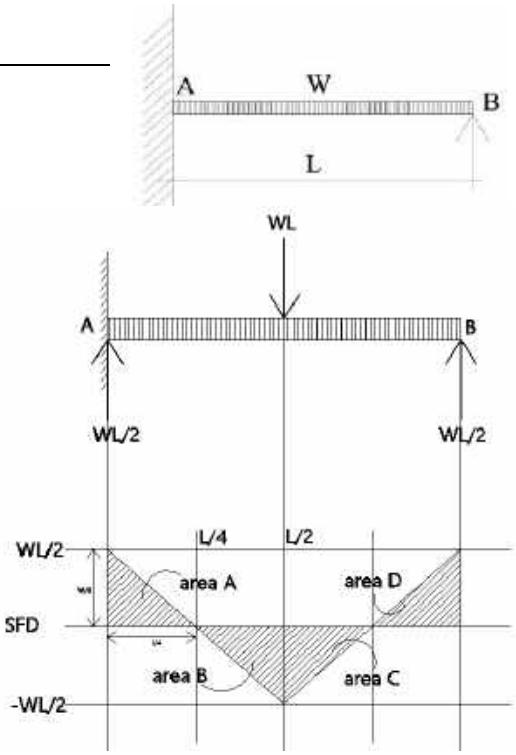
Q.7 Correct shear force diagram for the beam is

(A) P-1, Q-2, R-2, S-2 (B) P-1, Q-2, R-1, S-1 (C) P-1, Q-2, R-2, S-1 (D) P-1, Q-1, R-2, S-2

Q9. On street parking along a road kerb has provision for 45 degree angular parking with car spaces of 5.4 m by 2.5m. How many cars can be parked in 400m stretch along the kerb?
(A) 100 cars (B) 110 cars (C) 120 cars (D) 130 cars

Answer: (B) 110 cars
Solution: Thumb rule for car space of 2.5m*5m:
30◦ parking: , L = 0.58+5N
45◦ parking: L= 3.54 N+1.77
60◦ parking: L = 2.89N+2.16

Q10. Moment at the fixed end 'A' of the beam indicated below is
(A) $-WL^2/12$ (B) $-WL/16$ **(C) $-WL^2/8$** (D) $-WL/8$



Solution: Let's start from the basic. Unit of Moment is Newton-meter. In the question, W is UDL (uniformly distributed load). So, its unit is Newton /meter. Unit of length L is meter.
Now, unit of WL is (W Newton/meter)*(L meter) = WL Newton (which is essentially a force. So WL/16 is also a force, not a moment. Therefor options (B) and (D) are incorrect).

Now, you are left with options (A) and (D). You should try your luck. If not, you should know that the area in SFD (Shear Force Diagram) is actually a value of moment.
Here, Moment at A should be sum of area of triangle A & B.
Moment at A = Area ($\Delta A + \Delta B$) = Area [(1/2*WL/2*L/4) + (1/2*WL/2*L/4)] = $WL^2/8$ Answer

Q11. A 300 meter long and 6 m wide pathway is to be illuminated with 4000 lumen lamps having maintenance factor of 0.8 and coefficient of utilization 0.45. The desired average lux on the pathway is 6. What should be the spacing between the lamps?
(A) 20 m (B) 30 m (C) 40 m (D) 50m Answer: (B) 30 m

Solution: Area of the road to be illuminated = 300m x 6m = 1800sq.m.
We have,
E = (N x F x UF x MF) / A
Where , E = average illuminance over the horizontal working plane
N = number of luminaire
F = lumens per lamp
UF = Utilisation Factor for the horizontal working plane
MF = Maintenance Factor
A = area of the horizontal working plane

So, 6 = (N x 4000 x 0.8 x 0.45) / 1800
⇨ N = 8 lamps
Spacing = 300 / (8 +1) = 33.3 Answer.

Notes:
- Lumens measure total amount of light output
- Lux measure light intensity

Figure Lux meter

Here, ac is the virtual image of the chimney a'c'. We know the length of ac =0.26 cm and its scale is 1:10,000
Therefore, height of chimney a'c' = 0.26 cm * 10,000 = 26 meter **Answer.**

---

17. Explain the significance of 'Z' score in the statistical analysis and mention its properties.

Answer: **z Score**
A **z-score** (a **standard score**) indicates how many standard deviations an element is from the mean. A z-score can be calculated from the following formula.
$z = (X - \mu) / \sigma$
where z is the z-score, X is the value of the element, μ is the population mean, and σ is the standard deviation.
Here is how to interpret z-scores.

- A z-score less than 0 represents an element less than the mean.
- A z-score greater than 0 represents an element greater than the mean.
- A z-score equal to 0 represents an element equal to the mean.
- A z-score equal to 1 represents an element that is 1 standard deviation greater than the mean; a z-score equal to 2, 2 standard deviations greater than the mean; etc.
- A z-score equal to -1 represents an element that is 1 standard deviation less than the mean; a z-score equal to -2, 2 standard deviations less than the mean; etc.
- If the number of elements in the set is large, about 68% of the elements have a z-score between -1 and 1; about 95% have a z-score between -2 and 2; and about 99% have a z-score between -3 and 3.

Here is another way to think about z-scores. A z-score is the normal random variable of a standard normal distribution .
(Source: http://stattrek.com/statistics/dictionary.aspx?definition=z%20score)

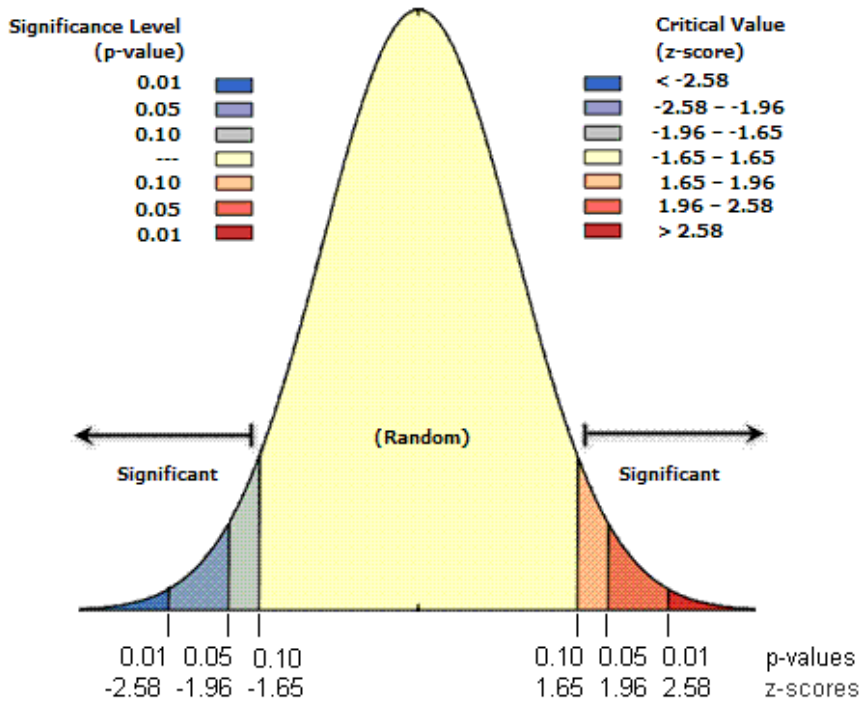


Figure: Z-score & P-value

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Activities on the critical path	t_o (days)	t_m (days)	t_p (days)	Mean $(t_o+4t_m+t_p)/6$	Standard Deviation, σ $(t_p - t_o)/6$	Variance, σ^2 Square of SD
A	5	10	15	10	1.67	2.79
B	8	16	24	16	2.27	5.15

We have already calculated σ for two activities – A & B. We now have to calculate standard deviation of the Critical Path. SD (standard deviation) of the Critical Path cannot be calculated by simply adding individual standard deviation σ. As per the Statistics, individual σ cannot be added together. In order to determine Critical Path SD, we have to first find Variance of the Critical Path.

Variance (Critical Path) = Variance(A)+Variance(B) = 2.79 + 5.15 = 7.94
As per the Statistics, σ can be determined by taking Square Root of Variance.
σ (Critical Path) = Square root of (Var(A)+Var(B)) = Square root of 7.94 = 2.82 Answer.

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8. Sketch a wall footing for a 250 mm wall of a two-storied residential building on a ground having a safe bearing capacity of 10 tons/m2 at a depth of 1 m below the surface. The load from the wall at the ground level is 7 tons/m length of the wall.

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9. Design illumination for a 6m x 4m computer lab so as to achieve good working environment. Ceiling height is 3m and the false ceiling is at 2.4m. Draw an inverted ceiling plan and a section of the room.

---

10. The passenger demand during the two hours morning peak period along a bus route is 4000 passengers. The round trip time along the route is 50 minutes and the average vehicle occupancy is 75 passengers. Calculate the hourly flow of buses and the number of buses required to provide this flow assuming 5% of the buses will be under service and repair.

---

11. A city with population of 1,00,000 discharges sewage of 120 lpcd in a stream having a flow of 1 cu.m/sec. The BOD content in the up-stream before the out fall is 0.8 mg/lit. Calculate the BOD content of the stream in mg/lit just down stream of outfall.

Solution: First, calculate discharge rate of sewage.

Q_w = (100000*120 litres)/(24*3600 seconds) = 139 litres/seconds = 0.139 cu.m /sec
L_w = 40mg/lit (assumed)
Q_r = 1 cu.m/sec (given)
L_r = 0.8 mg/lit (given)

$$L_0 = \frac{Q_r L_r + Q_w L_w}{Q_r + Q_w}$$

Where :
L_0 = Ultimate BOD at the point of waste discharge
Q_r = Flow in the river upstream of the discharge
L_r = Ultimate BOD of the river water
Q_w = Flow of wastewater from the discharge
L_w = Ultimate BOD in the discharged wastewater

$$L_o = \frac{1\ \text{cu.}\frac{m}{sec}*0.8\frac{mg}{lit} + 0.139\frac{cum}{sec}*0.8\frac{mg}{lit}}{(1+0.139)\text{cum/sec}} = 0.8\ \text{mg/lit Answer}$$

---

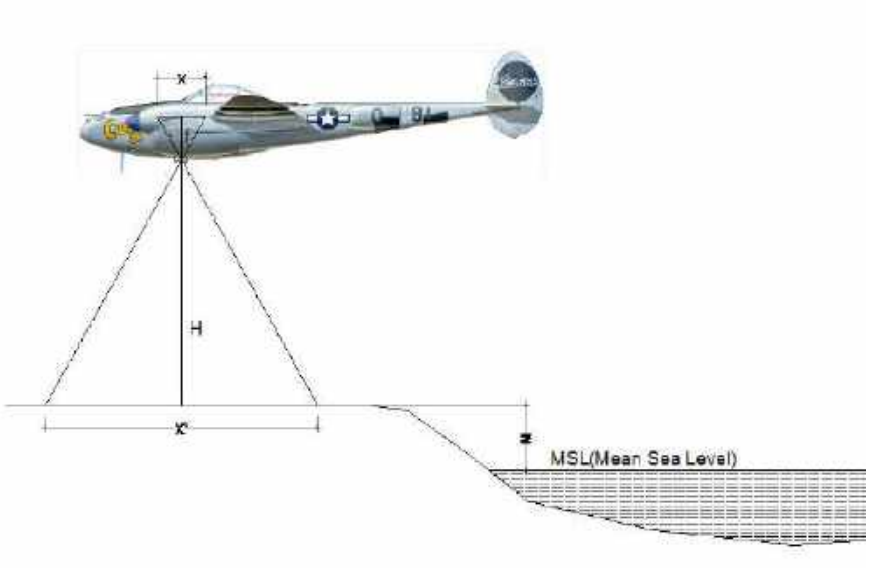
12. Determine the angle at which a pavement should be banked in order to avoid outward sliding of vehicles along a horizontal circular curve of radius R= 300m. The maximum allowable speed limit along the curve is 100 km/hour. The coefficient of side friction is 0.2.

Solution: *Given:* Coefficient of friction, **μ** = 0.2, Radius, **r** = 300m, Speed **v**, = 199 km/hr = 27.79m/sec

13. Aerial photograph on scale 1:25000 was taken with an aerial camera lens of 15 cm focal length. Calculate the flying height above mean ground level of 1200 m. Find the flying height of the aircraft above mean sea level.

Solution: Here, $\frac{f}{H} = \frac{x}{X'}$ => $\frac{0.15m}{H} = \frac{1}{25000}$ => H = 25000*0.15m = 3750m (Flying height above mean ground level)

Flying height of the aircraft above mean sea level = 3750 +1200 = 4950m Answer.



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Q1. Ratio 'Golden Mean' is:

(A) 1:2.261 **(B) 1 : 1.618** (C) 1: 1.15 (D) 1: 1.44

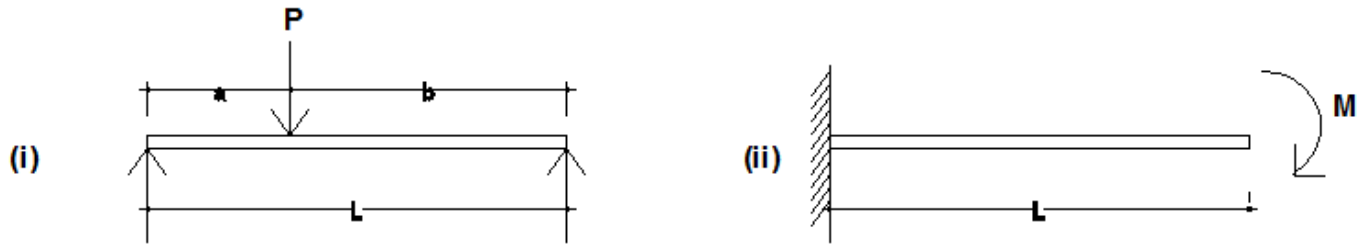
Q2. An urban area with a population of 2,15,000 is having housing stock of 39,000 and average household size of 5.0 . The city is expected to have 2,70,000 by 2001 with an average family size of 4.5, Estimate the housing demand of the city by 2001assuming there will be depletion of existing housing stock by 3,500 during this period.

Solution: Current Demand = Population / Household size = 2,15,000 / 5 = 43,000 Houses
Housing Demand in 2001 = Population / Household size = 2,70, 000 / 4.5 = 60,000 Houses
Demand difference = 60,000 – 43,000 = 17,000 Houses

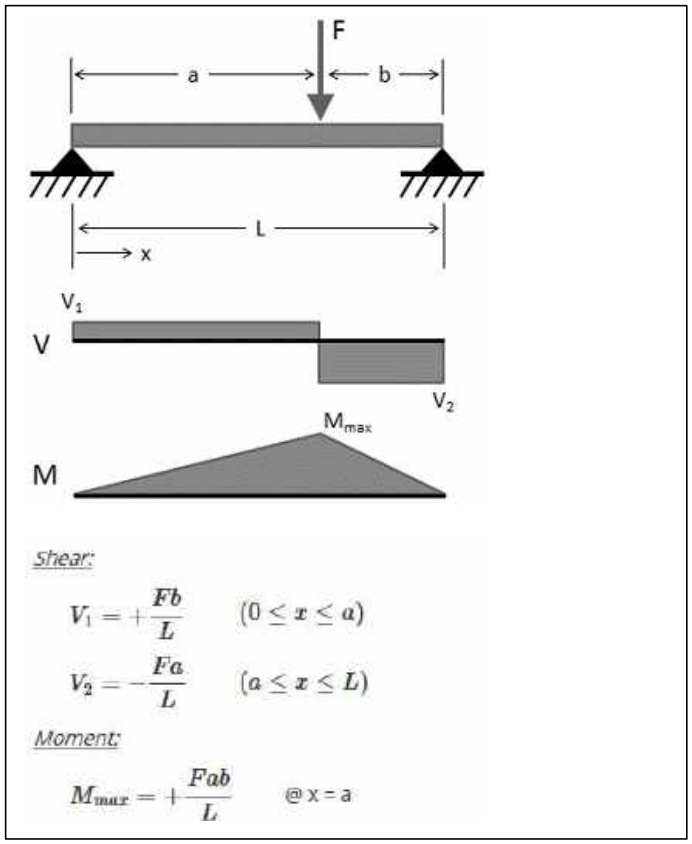
Initially we needed 43,000 houses but we had only 39,000. So, Initial Shortage = 43,000 – 39,000 = 4,000 Houses
Depleted Houses = 3,500 Houses

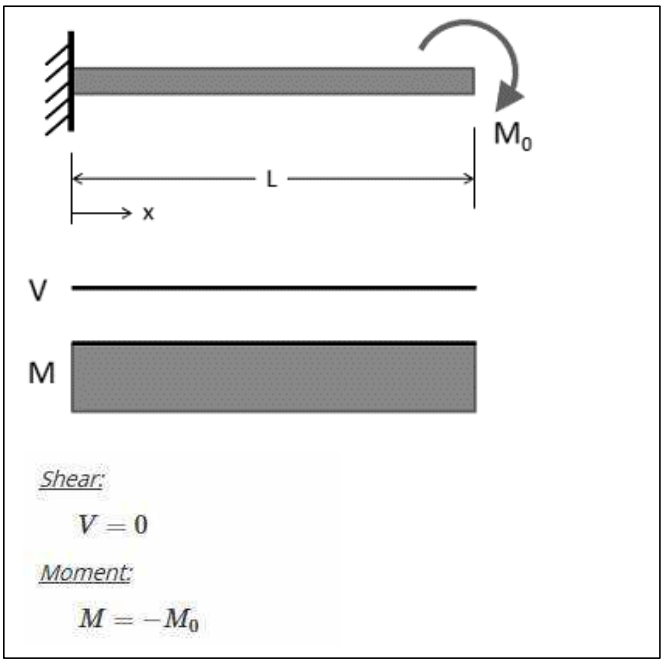
So, total demand = Demand difference + Initial shortage + Depleted houses = 17,000 + 4,000 + 3,500 = 24,500 Answer

Q3. Draw the bending moment and shear force diagrams for the following:



Solution:





Q4. The residential landuse of an urban area accounts for 50% of the developed land of the city. The vacant undeveloped land is about 30% of the total urban area, which amounts to 2,400 hectares of land. Estimate the quantum of land put to residential uses and also the overall density of the urban area if the population is of 2,00,000 size.

Solution: 30% of x = 2400 => $\frac{30}{100} * x = 2400$ => $\frac{30*x}{100} = 2400$ => $30*x = 240000$

=> x = $\frac{240000}{30}$ = 8000 hectares (It is total urban area)

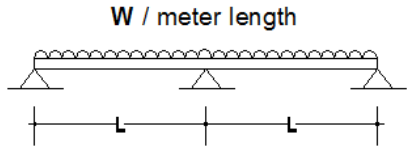
As per question, 70% of total urban area is developed land = 70% of 8000 = $\frac{560000}{100}$ hectare = 5600 hectare

As per question, 50% of 5600 hectare is residential landuse = 2800 hectare *Answer*

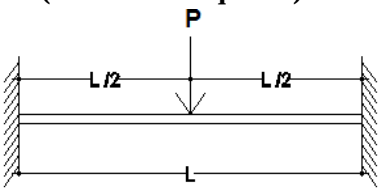
Population density = $\frac{\text{Population}}{\text{Total Area}} = \frac{2,00,000}{8000}$ = 25 person per hectare *Answer*

Q5. Sketch the bending moment and shear force diagrams (values not required)

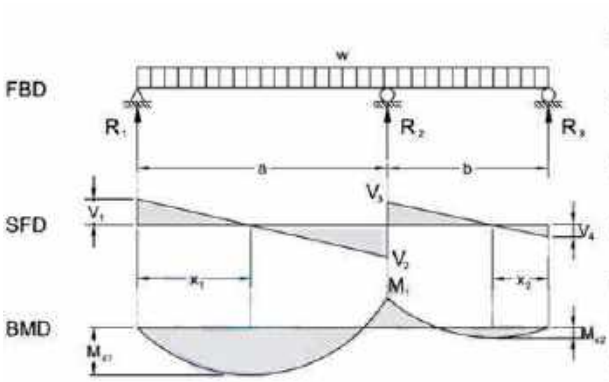
(i)



(ii)



Solution:



$$R_1 = V_1 \ldots\ldots = \frac{M_1}{a} + \frac{wa}{2}$$

$$R_2 \ldots\ldots = wa + wb - R_1 - R_3$$

$$R_3 = V_4 \ldots\ldots = \frac{M_1}{b} + \frac{wb}{2}$$

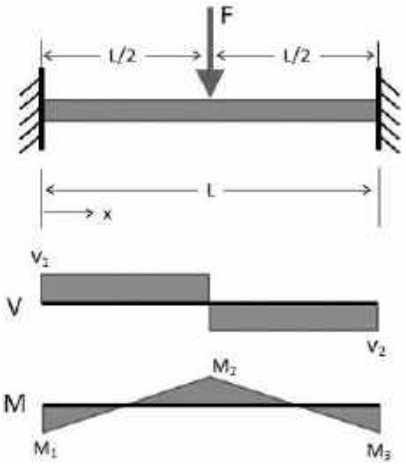
$$V_2 \ldots\ldots = wa - R_1$$

$$V_3 \ldots\ldots = wb - R_3$$

$$M_1 \ldots\ldots = -\frac{wb^3 + wa^3}{8(a+b)}$$

$$M_{x_1}\left(x_1 = \frac{R_1}{w}\right) \ldots\ldots = R_1 x_1 - \frac{wx_1^2}{2}$$

$$M_{x_2}\left(x_2 = \frac{R_3}{w}\right) \ldots\ldots = R_3 x_2 - \frac{wx_2^2}{2}$$



Shear:

$$V_1 = +\frac{F}{2} \qquad (0 \le x \le L/2)$$

$$V_2 = -\frac{F}{2} \qquad (L/2 \le x \le L)$$

Moment:

$$M = \frac{F}{8}(4x - L)^2 \qquad (0 \le x \le L/2)$$

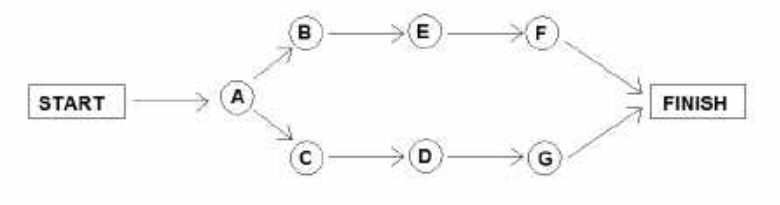
$$M_1 = M_3 = -\frac{FL}{8} \qquad @\ x = 0 \text{ and } x = L$$

$$M_2 = +\frac{FL}{8} \qquad @\ x = L/2$$

Q6. Draw the CPM network diagram with the activities as shown below:

Serial No.	Activity	Preceding activity
1	A	-
2	B	A
3	C	A
4	D	C
5	E	B
6	F	E
7	G	D

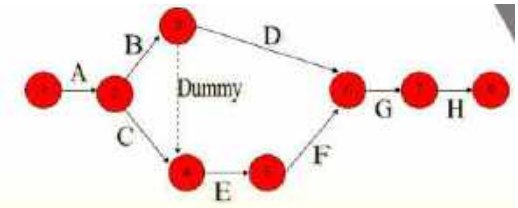
Solution:



Notes: Activity on Arc(AOA):

• Uses arcs to represent activities and nodes to represent events.

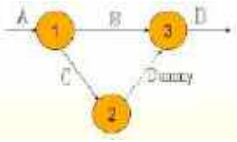
• It is Event Oriented.



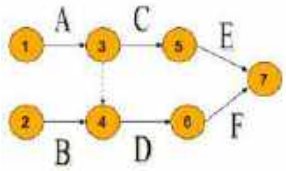
AOA approach requires the addition of a ***Dummy Activity*** to clarify the precedence relationships between the two activities. It is a zero time activity and consumes no resources.

Dummy Activity is used in two situations:

1) When two or more activities start and end at the same nodes.



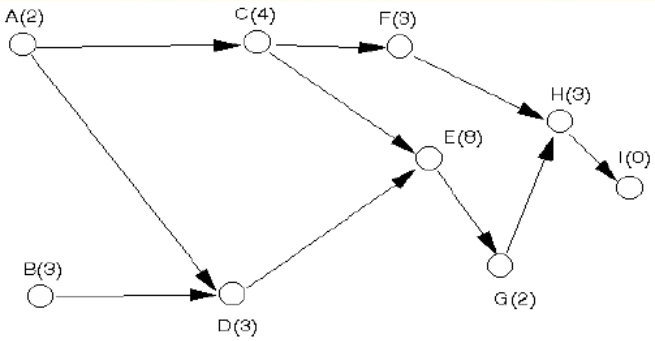
2) When two or more activities share the same precedence activity but not all the precedence are shared.



Activity on Node (AON):

Uses nodes to represent activities and arcs indicate precedence relationships between them.

It is Activity Oriented.



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