QUESTION BANK

Q&A *with* ESSENTIAL NOTES
For Architecture & Planning

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4 BOOKS

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In pursuit of constantly improving this book, we would delete or add contents without prior information!

SYLLABUS GATE 2022

Architecture and Planning (AR): New Pattern

> *New*
>
> The Paper contains General Aptitude (GA) section (15 Marks) as applicable for all papers of GATE 2022.
> The Paper consists of two parts covering the syllabus: Part A (60 marks) and Part B (25 marks).
> **Part A** is compulsory for all the candidates.
> **Part B** contains two **optional** sections: Part B1 (Architecture) and Part B2 (Planning).
> *Candidates have to choose any one of these during the examination! (Part B1 or Part B2)*

Highlighted texts below in yellow are the syllabus part from which questions were asked in GATE AR 2022 and the superscript in red are the question numbers.

Part A: General

Section 1: Architecture, Planning and Design

Architectural Graphics[13, 18]; Visual composition in 2D and 3D[40]; Computer application in Architecture and Planning; Anthropometrics; Organization of space; Circulation- horizontal and vertical[30s]; Space Standards; Universal design[16,17]; Building byelaws; Codes and standards;

Section 2: Construction and Management

Project management techniques e.g. PERT, CPM[46] etc. ;Estimation[47, 48] and Specification; Professional practice and ethics[21]; Form and Structure; Principles and design of disaster resistant structures[30q]; Temporary structures for rehabilitation;

Section 3: Environmental Planning and Design

Natural and man-made ecosystem[19, 38]; Ecological principles; Environmental considerations in Planning and design; Environmental pollution- types, causes[44], controls and abatement strategies; Sustainable development[22], goals and strategies; Climate change and built environment; Climate responsive design[20];

Section 4: Urban Design, landscape and Conservation

Historical and modern examples of urban design; Elements of urban built environment[77] –urban form, spaces, structure, pattern, fabric, texture, grain etc.; Concepts and theories of urban design; Principles, tools and techniques of urban design; Public spaces, character, spatial qualities and Sense of Place; Urban design interventions for sustainable development and transportation; Development controls – FAR[69], densities and building byelaws.; Urban renewal and conservation; heritage conservation[33]; historical public spaces and gardens; Landscape design; Site planning[25];

Section 5: Planning process

Salient concepts, theories and principles of urban planning; concepts of cities[32] - Eco-City, Smart City; Concepts and theories by trendsetting planners and designers[34, 35, 74, 75]; Ekistics; Urban sociology[49]; Social, Economic and environmental cost benefit analysis; Methods of non-spatial and spatial data analysis; Development guidelines such as URDPFI[36, 41];

Section 6: Housing

Housing typologies; Concepts, principles and examples of neighbourhood; Residential densities; Affordable Housing[12]; Real estate valuation[72, 80, 81];

Section 7: Services and Infrastructure

Firefighting Systems[30p]; Building Safety and Security systems; Building Management Systems; Water treatment; Water supply and distribution system[27, 30r, 45]; Water harvesting systems; Principles, Planning and Design of storm water drainage system; Sewage disposal methods; Methods of solid waste management - collection, transportation and disposal[28]; Recycling and Reuse of solid waste; Land-use – transportation - urban form inter-relationships; Design of roads, intersections, grade separators and parking areas[26]; Hierarchy of roads[15] and level of service; Para-transits and other modes of transportation, Pedestrian and slow moving traffic planning;

Part B1: Architecture

Section B1.1: History and Contemporary Architecture

Principles of Art and Architecture; World History of Architecture[39, 43, 51, 53, 57]: Egyptian, Greco-Roman classical period, Byzantine, Gothic, Renaissance, Baroque-Rococo, etc.; Recent trends in Contemporary Architecture: Art nouveau, Art Deco, Eclecticism, International styles, Post Modernism, Deconstruction in architecture, etc.; Influence of Modern art and Design in Architecture; Indian vernacular and traditional Architecture[31, 61], Oriental Architecture; Works of renowned national and international architects[37, 58];

Section B1.2: Building Construction and Structural systems

Building construction techniques, methods and details; Building systems and prefabrication of building elements; Principles of Modular Coordination; Construction planning[29] and equipment[60]; Building material characteristics and applications[50, 54]; Principles of strength of materials[52]; Alternative building materials; Foundations; Design of structural elements with different materials[59]; Elastic and Limit State design; Structural systems[14, 23, 56, 63]; Principles of Pre-stressing; High Rise and Long Span structures, gravity and lateral load resisting systems;

Section B1.3: Building Services and Sustainability

Solar architecture[11, 55, 65]; Thermal[24], visual[62] and acoustic[64] comfort in built environments; Natural and Mechanical ventilation in buildings; Air-Conditioning systems[42]; Sustainable building strategies; Building Performance Simulation and Evaluation; Intelligent Buildings; Water supply; Sewerage and drainage systems; Sanitary fittings and fixtures; Plumbing systems; Principles of internal and external drainage system; Principles of electrification of buildings; Elevators and Escalators - standards and uses;

Part B2: Planning
Section B2.1: Regional and Settlement Planning
Regional delineation; settlement hierarchy; Types and hierarchy of plans; Various schemes and programs of central government; Transit Oriented Development (TOD)[76], SEZ, SRZ etc.; Public Perception and user behaviour; National Housing Policies, Programs and Schemes.; Slums, Squatters and informal housing; Standards for housing and community facilities; Housing for special areas and needs;

Section B2.2: Planning Techniques and Management
Application of G.I.S and Remote Sensing techniques in urban and regional planning; Tools and techniques of Surveys – Physical, Topographical, Land use and Socio-economic Surveys; Urban Economics[67], Law of demand and supply of land and its use in planning; Graphic presentation of spatial data; Local self-governance, Panchayati Raj institutions; Planning Legislation and implementation – Land Acquisition Act, PPP[70] etc.; Decision support system and Land Information System; Urban geography and econometrics; Management of Infrastructure Projects; Demography and equity in planning;

Section B2.3: Infrastructure Planning
Process and Principles of Transportation Planning and Traffic Engineering[68]; Road capacity and Travel demand forecasting; Traffic survey methods, Traffic flow Analysis[71, 79]; Traffic analyses[73] and design considerations; Traffic and transport management and control in urban areas[66, 78]; Mass transportation planning; Intelligent Transportation Systems; Urban and Rural Infrastructure System Network.

General Aptitude (15 marks)
Verbal Aptitude
Basic English grammar[1]: tenses, articles, adjectives, prepositions, conjunctions, verb-noun agreement, and other parts of speech Basic vocabulary: words, idioms, and phrases in context Reading and comprehension[6] Narrative sequencing

Quantitative Aptitude
Data interpretation: data graphs (bar graphs, pie charts, and other graphs representing data), 2- and 3-dimensional plots, maps, and tables Numerical computation[7] and estimation: ratios[8], percentages[2,3], powers, exponents and logarithms, permutations and combinations, and series Mensuration and geometry Elementary statistics and probability

Analytical Aptitude
Logic[10]: deduction and induction, Analogy, Numerical relations and reasoning[4,9]

Spatial Aptitude
Transformation of shapes: translation, rotation, scaling, mirroring, assembling, and grouping Paper folding, cutting, and patterns in 2 and 3 dimensions[5]

Odeon is the most comprehensive software for room acoustics. It is developed for calculating, simulating, and measuring the interior acoustics of relevant buildings. With the appropriate treatment even outdoor situations can be studied. It is ideal for the prediction of acoustics in concert halls, opera halls, auditoria, foyers, underground stations, airport terminals and industrial workrooms, as well as office environments, smaller lecture rooms, open-air venues, patios and atria.

Adobe Dreamweaver is a software for designing web pages. These HTML web pages are fully featured. This software provides a WYSIWYG i.e., 'What You See Is What You Get' interface for creating and editing the web pages. The Adobe Dreamweaver software supports many markup languages like HTML, XML, CSS, and JavaScript. It supports English, Spanish, French, German, Japanese, Chinese and others. The Dreamweaver was developed by Macromedia, and it was published in 1997. In 2005 the Adobe had purchased Dreamweaver and name it as Adobe Dreamweaver.

DesignBuilder has been developed to be used by a wide range of professionals such as architects, engineers, building services workers, energy consultants and related departments of universities. Some typical usage purposes are summarized below:

- To evaluate facade options in terms of overheating, energy consumption and shading parameters.
- Evaluation of the optimum use of daylight. Modelling of lighting control systems and determining the savings rate in the corresponding electricity.
- To calculate the buildings in/around temperature, velocity and pressure distribution by using the CFD (Computational Fluid Dynamics) module.
- Visualization of the site plan and shading.
- Thermal simulation in buildings which are ventilated with natural ventilation.
- Determining the capacity of heating and cooling equipment to include the issues to help HVAC design.
- To provide material to design meetings for supporting interdisciplinary communication.
- To be used in universities in energy modeling and simulation courses.

Q.14 The main cable of a suspension bridge supports the deck with hangars. These hangars are equidistant along the length of the bridge and represent a uniformly distributed load. Assuming the cable to be weightless as compared to the applied loading, the best approximation of the shape that the cable takes for this loading is a _____. (1 mark)
(A) Catenary curve (B) Circular arc (C) Parabolic curve (D) Hyperbolic curve
Option (A) is wrong because a catenary curved is formed when its element has some weight and the whole system is influenced by the force of gravity only. But in the question, the self-weight of the element has been ignored. In the above question, the main cable can be considered as a simply supported beam at two ends and the hangers as UDL (uniformly distributed load). The deflection of a simply supported beam due to UDL conceives a parabolic profile.

Figure: Example of a catenary curve.

Q.15 Arrange the following road types in descending order of accessibility.
(P) Arterial Road   (Q) Expressway   (R) Collector Road   (S) Local Street
(A) Q-P-R-S   (B) S-R-P-Q   (C) S-P-R-Q   (D) P-Q-S-R
Explanation: Local street is most accessible. (1 mark)

Q.16 The following two-dimensional visual composition represents _____. (1 mark)
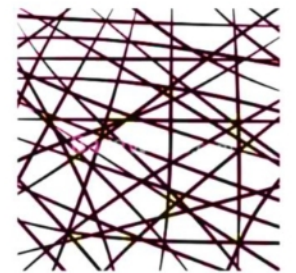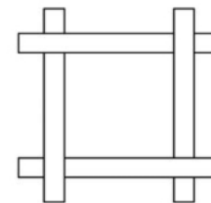(A) Interlocking   (B) Intersecting   (C) Interlacing   (D) Interpenetrating

Figure: Intersecting pattern

Q.17 The Golden Ratio refers to _____.   (A) 1:√2 (B) 2:(1 +√5) (C) 1:1 (D) 16:9 (1 mark)

The golden ratio *(symbol is the Greek letter "phi" or "phai")* is a special number approximately equal to 1.618

It appears many times in geometry, art, architecture and other areas.

To get golden ratio, a line is divided into two parts so that:

the whole length divided by the long part

is also equal to

the long part divided by the short part

golden ratio: (a+b)/a = a/b = 1.61803398874989484820... It continues, with no pattern. Essentially, the Golden Ratio is known to be an irrational number.

Figure: Interlocking pattern

Formula derivation:
$\frac{a}{b} = \frac{a+b}{a}$
Splitting the right-hand fraction:
$\frac{a}{b} = \frac{a}{a} + \frac{b}{a}$
$\frac{a}{b}$ is the Golden Ratio φ, $\frac{a}{a} = 1$ and $\frac{b}{a} = \frac{1}{\varphi}$, which results in:
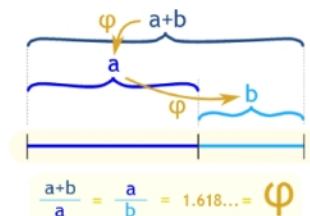$\varphi = 1 + = \frac{1}{\varphi}$

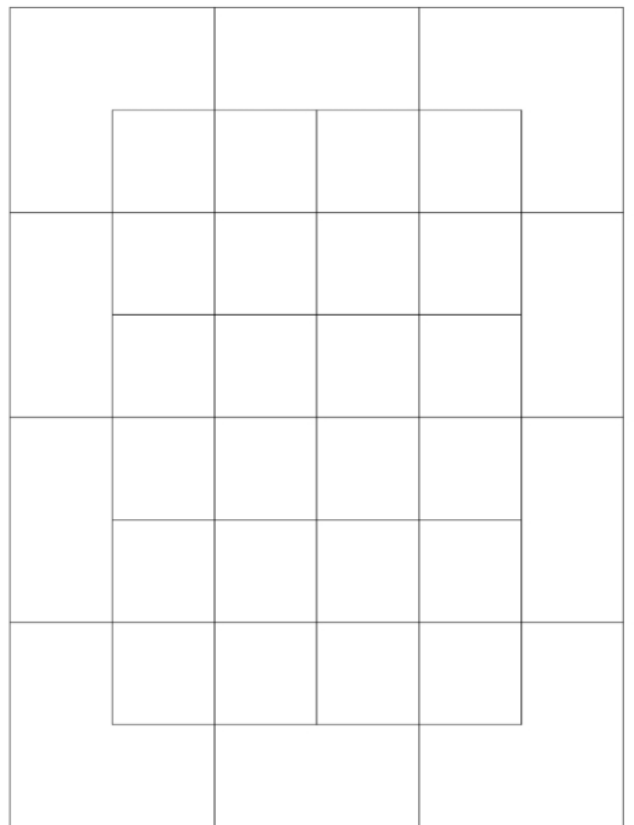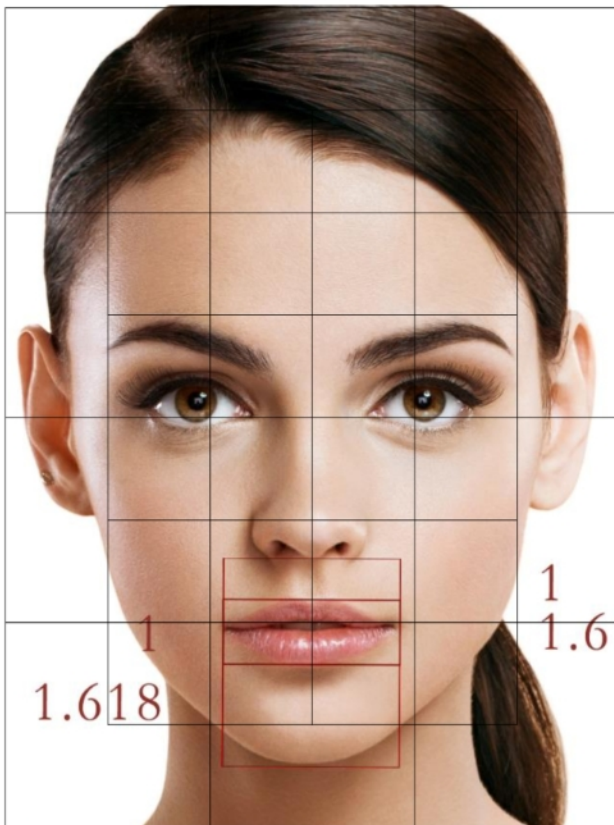$\frac{a+b}{a} = \frac{a}{b} = 1.618... = \varphi$

Figure: Example of golden ratio in human anatomy. #Sketch2Remember

Q.18 Hogarth's *Line of Beauty* is a _____. (1 mark)

(A) Horizontal straight line (B) Zigzag line (C) Vertical straight line (D) Serpentine line

The artist William Hogarth wrote a book called The Analysis of Beauty. He proposed that the essence of beauty of line in painting, drawing, nature and design is not the simple geometry of a straight line or circle, or more subtle shapes such as the ellipse, but of curves that modulate from one gradient to another. Such a curve, the "S" curve is such a structure, and he called it "the line of beauty". According to his theory, S-Shaped curved lines signify liveliness and activity and excite the attention of the viewer as contrasted with straight lines, parallel lines, or right-angled intersecting lines which signify stasis, death, or inanimate objects. He goes on to say that the S curve is the basis of all great art. (https://nicholaswells.com/hogarths-line-of-beauty/)

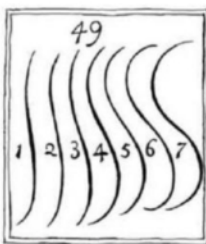Figure: Self portrait of William Hogarth.

Figure: From the book 'The Analysis of Beauty' by William Hogarth. He quotes "Though all sorts of waving-lines are ornamental, when properly applied; thou, strictly speaking, there is but one precise line, properly to be called the line of beauty, which in the scale of them is number 4: the lines 5,6,7 by their bulging too much in their curvature becoming gross and clumsy; and, on the contrary, 3, 2, 1, as they straighten, becoming mean and poor…"
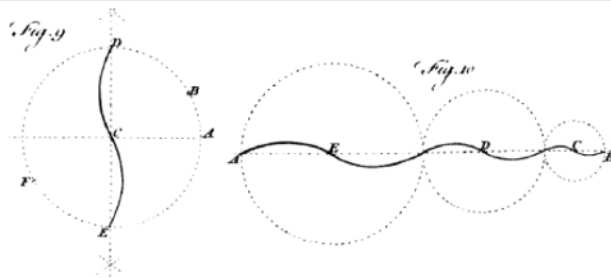
Figure: An attempt to illustrate what William Hogarth termed "the line of beauty."
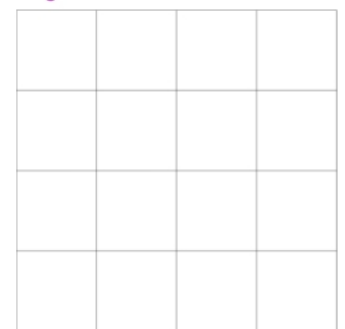
Figure: Gestalt optical illusions illustrate how our perception creates a shape that is not in fact there. With the image on the left, a sphere is visualized in the center with conical objects extruding out from it. In reality, there is no sphere and there are no protruding cones; the illusion of three dimensions is a product of how the entire image is cognitively processed. Instead of being understood as a number of discrete elements, it is understood as a whole and acquires meaning. The same effect can be considered for the image to the right. (L. Urquhart & A. Wodehouse 2018)

Length of side of a BIG square (adding all 9 small squares) = 10m – 4 x 0.3 = 8.8 m
Volume of 9 depressions (BIG square) = 8.8m x 8.8m x 0.45m = 34.85m^3
So, Volume of reinforced concrete roof = 60 – 34.85 = 25.15 m^3
99% of 25.15 m^3 = 24.90 Answer

Q.49 The following graph represents the income distribution among the population of a country. The *Gini Coefficient* of the country (rounded off to three decimal places) is _____. (2 marks)
Solution:

Gini coefficient = Pink/Blue

Area of Purple = 1/2*30*18 = 270
Area of Green = 1/2*(18 + 45)*40 = 1260
Area of Orange = 1/2*(45 + 100)*30 = 2175

Area of Pink = Blue - (Purple + Green + Orange)
Area of Pink = 5000 - (270 + 1260 + 2175)
Area of Pink = 1295

Gini coefficient = 1295/5000 = 0.26

Part B1 Architectural Section: Optional (Attempt either B1 or B2)
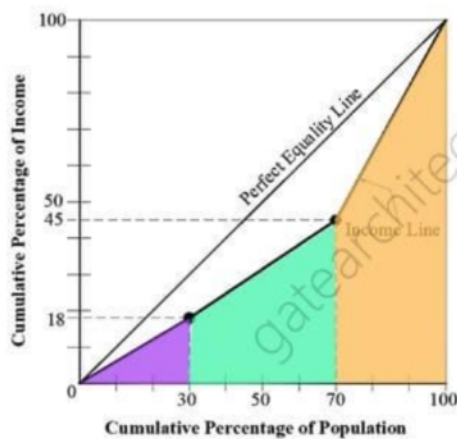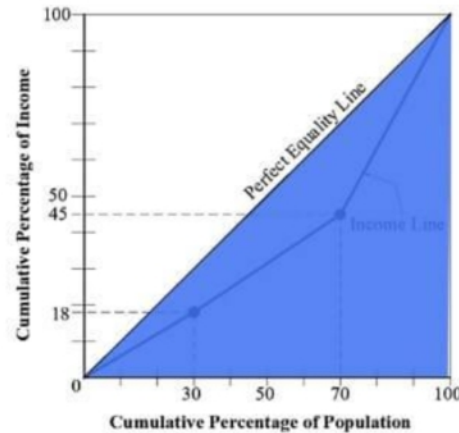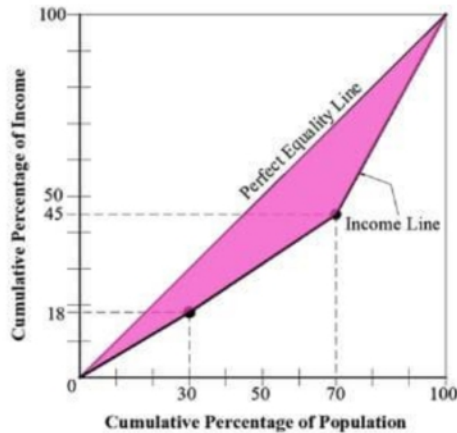
Q.50(B1) Which of the following processes is used for surface treatment of metals?
(A) Soldering (B) Thermoplating (C) Extrusion (D) Riveting

Thermoplating is the process in which the object or the metal to be coated is heated first and then a coating of another molten metal is applied on it. In this process heat is used for coating. Example: 'Tinning' of brass utensils is a thermoplating process in which the utensils are heated first, and then a coating of molten tin is applied.
Electroplating is the process where; electric current is used to plate the object or metal.

Q.51(B1) Among the following monuments of ancient Greece, the only Octastyle Peripteral temple with eight towering Doric columns lining both east and west facades is _____.
(A) Temple of Athena (B) Temple of Apollo (C) The Parthenon (D) Temple of Horus

Octastyle temple: It is an adjective in architecture having eight columns in the front, as a temple or portico.
Octastyle peripteral temple with hexastyle portico: A method of designating or distinguishing the temples is by the number of columns in front, thus temples are called tetrastyle, hexastyle, octastyle, that is having five, six, or eight columns. It was peripteral, octastyle; that is, surrounded by a portico of columns, with eight to each façade.
Portico: It formed the entrances to ancient Greek temples. The portico is a principal feature of Greek temple architecture and thus a prominent element in Roman and all subsequent classically inspired structures.

27	EPRS	Estidama Pearl Rating System	Abu Dhabi	2007
28	SICES	Sustainable Building Rating Tool/Sistema de Calificación de Edificación Sustentable	Mexico	2008
29	NGBS	National Green Building Standard	America	2008
30	AQUA-HQE	Alta Qualidade Ambientale	Brasil	2008
31	LiderA	The Sistema de Acaliacao da Sustentabilidade (Certification System of Environmentally Sustainable Construction)	Portugal	2008
32	ITACA Protocal	Protocollo Itaca	Italy	2009
33	GBI	Green Building Index	Malaysia	2009
34	BERDE	Building for Ecologically Responsive Design Excellence	Philippine	2009
35	GSAS	Global Sustainability Assessment System	Qatar	2009
36	VERDE	Herramienta VERDE	Spain	2009
37	GPRS	Green Pyramid Rating System Levels	Egypt	2010
38	LOTUS	-	Vietnam	2010
39	GREENSHIP	-	Indonesia	2010
40	TREES	Thai's Rating of Energy and Environmental Sustainability	Thailand	2010
41	BNB	Assessment System for Sustainable Building	Germany	2010
42	ARZ BRS	ARZ Building Rating System	Lebanon	2012
43	EDGE	Excellence in Design for Greater Efficiencies	America	2014
44	WELL	-	America	2014

Source: Yinqi Zhang, et al, 2019. A Survey of the Status and Challenges of Green Building Development in Various Countries, MDPI

Q.27 Match the buildings in Group I with their corresponding architect in Group II.

Group I
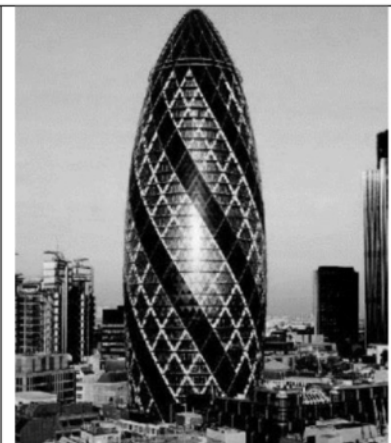
| P | Q | R | S |

Group II

| (1) Renzo Piano | (2) Daniel Libeskind | (3) David Childs | (4) Frank Owen Gehry | (5) Norman Foster |

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

BS (Blind Shot)					
Options given in the question	**P**	**Q**	**R**	**S**	Analysis
	4	3	1	2	The BS predicts that P should be matched with 2, Q should be matched with 3, R should be matched with 4. S should be matched with 5. Therefore, the predicted answer should be option (D). The true answer is also the same option (D).
	2	4	2	5	
	3	5	4	1	
	2	3	4	5	
Most repeated options	2	3	4	5	Result: BS predicts **right** answer!

Figure: The Shard building, London by Renzo Piano

Q.47 Reading in the staff stationed at P measured by a dumpy level is 3.5 m. The dumpy level is stationed at Q. The Reference Level (RL) at point P is 96.5 m and the height of the dumpy level is 1.25 m. The RL at point Q is …………… m. [round off to 2 decimal places]
Answer: 98.75 to 98.75

Solution: If we subtract the height of dumpy level i.e. 1.25 m from the reading of dumpy level i.e. 3.5 m, we get the height H that above RL at point P. So, H = 3.5 – 1.25 = 2.25 m

As shown in the figure, point Q is above point P. Therefore, RL at point Q = 96.5 + 2.25 = 98.75 Answer

Q.48 A building is constructed on a plot measuring 70 m × 40 m. The utilized FAR of the building is 1.5. An energy audit team found that the average monthly electricity bi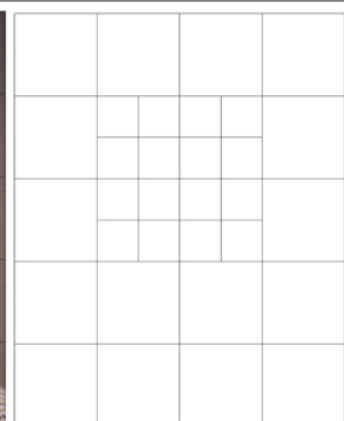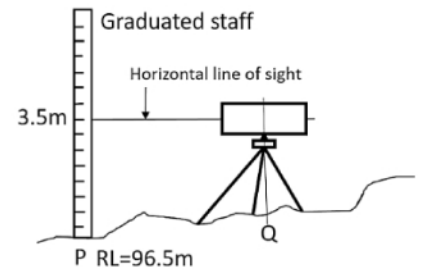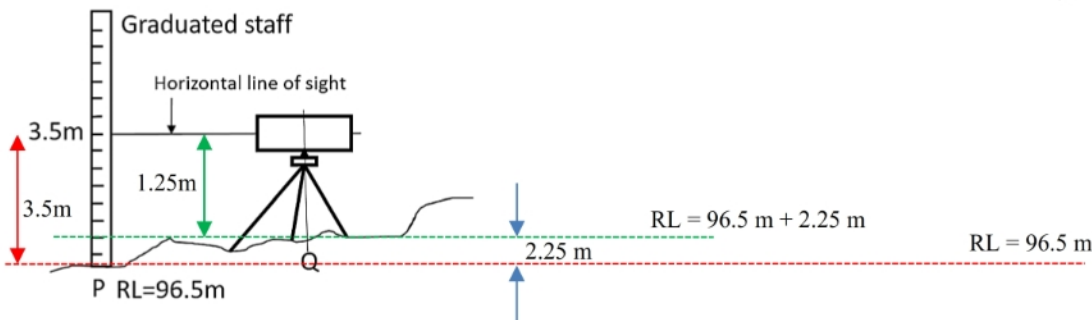ll of the building is INR 2,94,000. The unit cost of the electricity is INR 7. The Building Energy Index is _____ kW-hr/m^2 /year. [in integer] *Answer: 120*

Solution: To solve this question, you do not need to know what is Building Energy Index. Just look at the unit of Building Energy Index given in the question itself that is kW-hr/m^2 /year.
To solve this question, you should know that 1 unit of electricity = 1kW-hr
We need to calculate how much units of electricity are consumed in a year.
Annual electricity cost = 12 x INR 2,94,000 = INR 3528000 / year
Units of electricity = $\frac{INR\ 3528000}{INR\ 7}$ = 504000 units / year = 504000 kW-hr / year
Total built-up area = FAR * Plot area = 1.5 * (70 m*40 m) = 4200 m^2
Building Energy Index = $\frac{504000\ kW-hr/year}{4200\ m^2}$ = 120 kW-hr/m^2 /year Answer

Q.49 A simply-supported steel beam made of an I-section has a span of 8 m. The beam is carrying a uniformly distributed load of 15 kN/m. The overall depth of the beam is 450 mm. The moment of inertia of the beam section is 18000 cm^4. The maximum bending stress in the beam will be _____ N/mm^2. [in integer] *Answer: 150*

Solution: Bending stress = My / I
Where,
M = Maximum Bending Moment = wl^2/8 = (15 kN/m)*(8 m)^2 / 8 = 120 kN-m
y = Distance from neutral axis of the beam = 450 mm / 2 = 225 mm = 0.225 m
I = Moment of inertia = 18000 cm^4 = 18000 (10 mm)^4 = 18000000 mm^4

Therefore, Bending stress = (120 * 1000 N-m * 0.225 m) / 18000000 mm^4
= (120 * 1000 N * 1000 mm * 225 mm) / 18000000 mm^4
= 150 N/mm^2 Answer

Q.50 A circular cricket field of 180 m diameter is illuminated by four floodlight towers. The floodlight towers are equally spaced along the perimeter of the field. The height of the floodlight tower is 48 m. Using 'Inverse Square Law', the illumination level at the center of the field is found as 750 Lux. Each tower is consisting of 50 lamps. The rating of each lamp is 700 Watt. The efficacy of each lamp is ………. Lumen /Watt. [round off to 2 decimal places] *Answer: 117 to 119 or 1483 to 1496*

Solution: It seems, the question needs more data. Question could not be solved for the answer that could fit in the official GATE answer range of 117 to 119 or 1483 to 1496.
The answer range 1483 to 1496 Lumen/Watt is never possible.
The greatest luminous efficacy which can theoretically be achieved is 683 lm/W. However, in practice, this value cannot be reached, since, if this were so, it would mean that 1 Watt of physical radiant power can be converted loss-free into visible light.
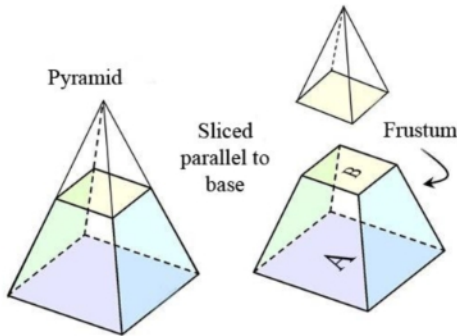
Part I, Volume = Base area * 0.4m = (2m x 2.5m) * 0.4 = $2m^3$

Part II, Volume = Average base area * 0.5m = $\frac{(2m \times 2.5m)+ (0.4m \times 0.5m)}{2}$ * 0.5m = $2.51m^2*0.5m = 1.23$ m^3

Part III, Volume = Column cross sectional area * 1.1m = (0.4m x 0.5m) * 1.1m = 0.22 m^3

Total volume = 2 + 1.23 + 0.22 = 3.43m^3

Please note that volume of the Part II is not accurate (Average area used for faster calculation). It is actually a frustum.

Pyramid

Sliced parallel to base

Frustum

Volume of Frustum = 1/3* h*(A + B + $\sqrt{AB}$) = 1/3*0.5*(5 + 0.2 + $\sqrt{5}x0.2$) = 1/3*0.5*6.2 = 1.03 m^3
(Official GATE answer range is 3.1 to 3.4)

Section A-A

Plan

Q.19 The activity duration, early start, early finish, late start and late finish of the three activities 'P', 'Q' and 'R' are shown in the following figure. The **independent float** of activity 'Q' is

2	P	9		9	Q	15		22	R	27
8	7	15		21	6	27		27	5	32
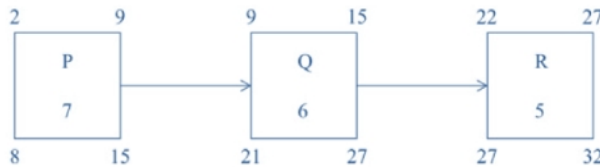
Solution: Independent Float
= ES of succeeding activity – LF of preceding - Duration of the activity of which Independent Float is to be counted
= ES of R – LF of P – Duration of Activity Q
= 22 – 15 – 6
= 1 Answer
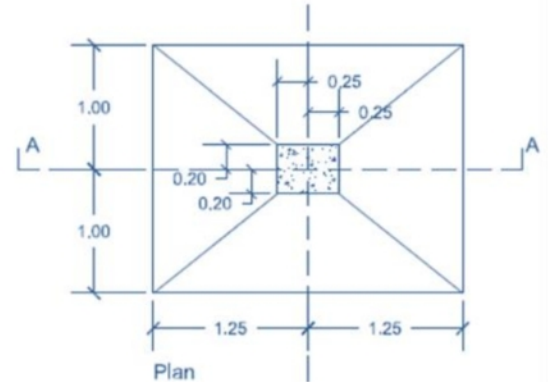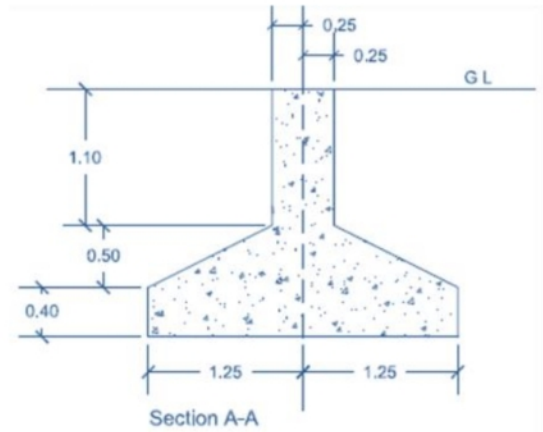
Scan for video lecture on Total float & Free float.

Scan for video lecture on Independent float

Q.20 A population of 2500 persons requires a minimum area of 3000 m^2 for primary schools. For the population in four different sectors given in the table below, the **Sector** having maximum shortage of school area per person is _____.

Sector	Population	Number of existing schools	Existing area of each school (m²)
1	20000	5	2000
2	15000	4	4500
3	12500	2	2500
4	10000	4	1500

Q.46 The solar protection system consisting of fixed slats or grids, outside a building façade in front of openings, is known as
(A) Brise soleil (B) Solarium (C) Malqaf (D) Trombe wall

Brise soleil	Solarium	Malqaf	Trombe wall
Brise soleil is an architectural feature of a building that uses a series of horizontal or vertical blades to control the amount of sunlight and solar heat that enters a building.	Solarium is a glass-enclosed porch or room used especially for sunbathing or therapeutic exposure to light. Sometimes, artificial light near to daylight spectrum is used in an enclosure.	Malqaf is a part of a complete ventilation system, consisting of a large shaft rising high above the roof of a building. The system of ventilation developed depends primarily on air movement by pressure differential, but also secondarily on air movement by convection.	Trombe walls are a type of technology that can be installed in homes to passively heat the building. The inclusion of Trombe walls reduces the need to heat the building using traditional methods such as furnaces or heaters.

Q.47 The Indian property inscribed by UNESCO on the World Heritage List in the year 2018 is
(A) Mattanchery Palace, Ernakulam
(B) The Victorian Gothic and Art Deco Ensembles of Mumbai
(C) Ancient Buddhist Site, Sarnath
(D) Mughal Gardens in Kashmir

The Victorian Gothic and Art Deco Ensembles of Mumbai is a collection of 19th century Victorian Neo Gothic public buildings and 20th century Art Deco buildings in the Fort area of Mumbai.

The Victorian Gothic and Art Deco Ensembles of Mumbai were inscribed in the World Heritage Sites (WHS) list at the 42nd session of the World Heritage Committee of UNESCO at Manama in Bahrain. Spread over 66.34 hectares with a buffer zone of 378.78 hectares, the Ensemble comprises two architectural styles – the 19th century collection

Figure: Bombay High Court building in Mumbai, India

Figure: Chhatrapati Shivaji Maharaj Terminus, Mumbai

of Victorian structures and the 20th century Art Deco buildings along the sea, conjoined by means of the historical open space of the Oval Maidan. As recommended by the World Heritage Committee, the heritage precinct is set to be renamed as 'Victorian Gothic and Art Deco Ensembles of Mumbai' shortly.

(Source: https://mumbaimirror.indiatimes.com/mumbai/other/mumbais-famed-victorian-gothic-and-art-deco-on-unesco-heritage-list/articleshow/64805725.cms)

Q.48 Typical features of Buddhist architecture are
(A) Mandapa, Chattri, Amalaka, Torana
(B) Stambha, Torana, Vimana , Harmika
(C) Vedika, Chattri, Torana, Harmika
(D) Vedika , Stupa, Chaitya, Vimana
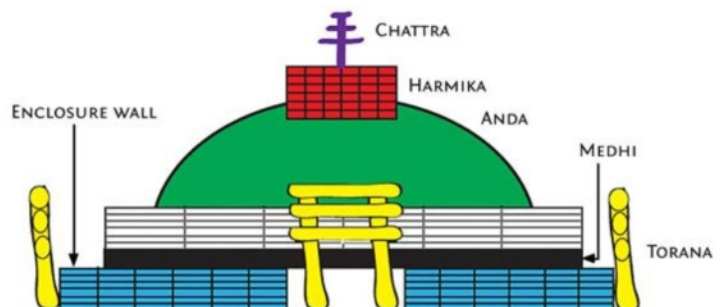
Solution: The rank size rule states that the *nth* largest city in a given country will have 1*n* of the population of the largest city in that country. If the largest city has a population 1,000,000, and we want to know the population of the fourth largest city, it will have 1/4 of the population of the largest city. 1/4 of 1,000,000 is 250,000 people.

Gravity Model is a model in urban geography derived from Newton's law of gravity, and used to predict the degree of interaction between two places.

Calculating Interaction, $S = (P_1 \times P_2)/(D \times D)$ Where, P_1 is the population of Place 1, while P_2 is the population place two. D is the distance between them.

Concept of Entropy is borrowed from the statistical theory of information. Entropy helps to measure disorder in settlement patterns. Then random and uniform components in such patterns are effectively separated and measured. It is possible to state definitively how many populated places constitute each of the uniform and the random components.

Source: https://link.springer.com/article/10.1007/BF01940320

Q.53 Match the instruments in Column - I with the various types of surveying in Column - II and select the appropriate option.

Column I	Column II	Options
P. Cross staff	1. Indoor wall to wall measurement	(A) P-3, Q-4, R-2, S-5
Q. Alidade	2. Traversing	(B) P-2, Q-4, R-1, S-5
R. Sextant	3. Chain survey	(C) P-5, Q-3, R-2, S-1
S. Distomat	4. Plane table survey	(D) P-3, Q-4, R-2, S-1
	5. Contour survey	

Most repeated option:	P-3 Q-4 R-2 S-5,1
Probable answer:	(A) & (D)
Predicted answer was:	Right

Distomat (a trade name just like Xerox for a photocopier machine) was never manufactured to measure inside a room. The answer (D) would be correct only if Distomat is meant to be an E.D.M (Electronic Distance Measurement) instrument.

SIGHT VANE
OBJECT VANI
BEVELLED EDGE
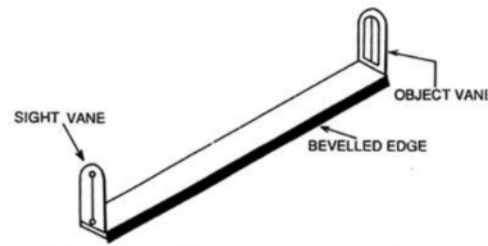
Figure: A sighting device or pointer for determining directions or measuring angles, used mainly in surveying.

SEXTANT

glass filter
horizon mirror
glass filter
screw to regulate small mirror
index arm
drum

index mirror
telescope
telescope clamp
eyepiece
telescope printing
frame
graduated arc
locking device
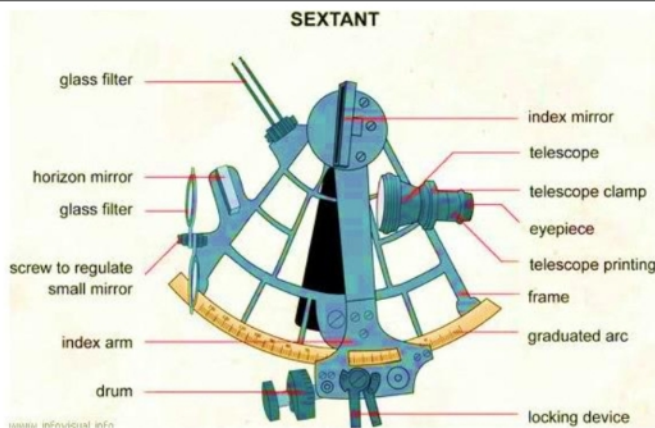
Figure: A sextant is a doubly reflecting navigation instrument used to measure altitude or the angle between any two visible objects. Sextant is one of the oldest navigation instruments used by mariners, its called sextant because its arc is 1/6th of a circle i.e. 60° but it can measure angles upto 120° using double reflection principle.

This half a mirror
This half transparent

A → ← C

Ship reflected by 1 via 2 to eyepiece.
1 turning.
Star reflected from 1 via 2.

Sextant Arc Scale marks
1/2 difference of angle
A to C.
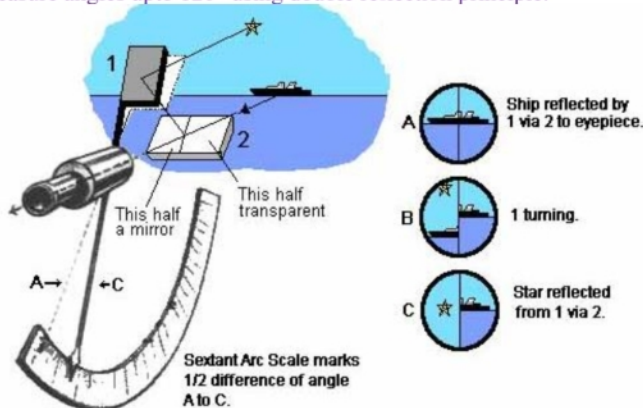
Figure: Distomat is the trade name of E.D.M (Electronic Distance Measurement) manufactured by LEICA Company of Switzerland. This instrument uses infrared light as signals. It is a very small, compact EDM instrument, particularly useful in building construction and other Civil Engineering works, where distance measurements are less than 500 m. It is an EDM that makes the meaning tape redundant. Through EDM, Direct measurement of distances and their directions can be obtained by using electronic instruments that rely on propagation, reflection and reception of either light waves or radio waves.

Design With Nature (1969) by Ian McHarg, comprises three parallel exhibitions and related programs focused on expanding the public's understanding of ecological approaches to design. He argued in his book that cities and their entire infrastructures should be planned in accordance with how the landscape functions as an ecosystem: design *with*, not against, the way nature works.

Source: https://www.pewcenterarts.org/grant/design-nature-now
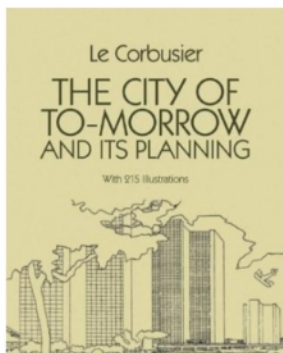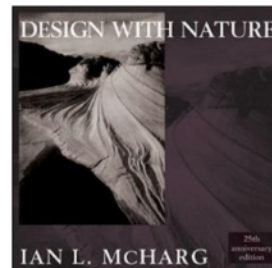
The City of To-morrow and Its Planning by Le Corbusier characterizes European cities as a chaos of poor design, inadequate housing, and inefficient transportation that grew out of the unplanned jumble of medieval cities. Developing his thesis that a great modern city can only function on a basis of strict order, Le Corbusier presents two imposing schemes for urban reconstruction — the "Voisin" scheme for the center of Paris, and his more developed plans for the "City of Three Million Inhabitants," which envisioned, among other things, 60-story skyscrapers, set well apart, to house commercial activities, and residential housing grouped in great blocks of "villas."

Source: https://www.goodreads.com/book/show/913269.The_City_of_Tomorrow_and_Its_Planning

Figure: Book *Earthscape* by John O Simonds

Q.56 Match the thermal properties in the Column - I and their respective units in Column - II and select the appropriate option.

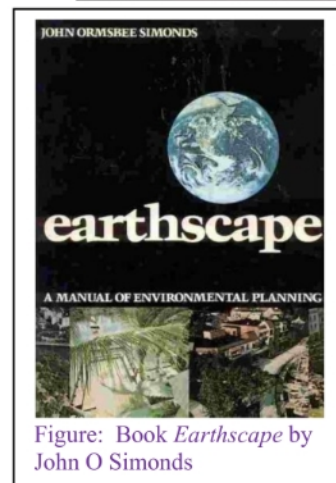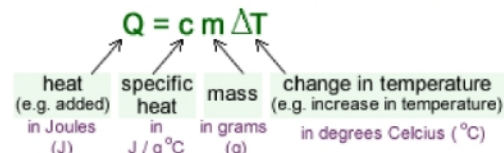| Column I	Column II	Options
P. Thermal Resistance	1. $J\ kg^{-1}\ °C^{-1}$	(A) P-4, Q-1, R-5, S-2
Q. Thermal Transmittance	2. $W\ m^{-1}\ °C^{-1}$	(B) P-4, Q-3, R-1, S-2
R. Specific Heat	3. $W\ m^{-2}\ °C^{-1}$	(C) P-5, Q-3, R-1, S-4
S. Thermal Conductivity	4. $m^2\ °C\ W^{-1}$	(D) P-3, Q-4, R-2, S-1
	5. $J\ m^{-3}\ °C^{-1}$	

Most repeated option:	P-4	Q-3	R-1	S-2
Probable answer:	(B)			
Predicted answer was:	Right			

Thermal Resistance: The heat flow through a building construction depends on the temperature difference across it, the conductivity of the materials used and the thickness of the materials. Of course, the temperature difference is an external factor. The thickness and the conductivity are properties of the material. A greater thickness means less heat flow and so does a lower conductivity. Together, these parameters form the thermal resistance of the construction. The thermal resistance is proportional to the thickness of a layer of the construction and inversely proportional to its conductivity. A construction layer with a high thermal resistance (e.g. rock wool), is a good insulator; one with a low thermal resistance (e.g. concrete) is a bad insulator. Its unit is m²K/W

Thermal Transmittance: Thermal transmittance, also known as U-value, is the rate of transfer of heat through a structure (which can be a single material or a composite), divided by the difference in temperature across that structure. The units of measurement are W/m²K. The better-insulated a structure is, the lower the U-value will be. Workmanship and installation standards can strongly affect the thermal transmittance. If insulation is fitted poorly, with gaps and cold bridges, then the thermal transmittance can be considerably higher than desired. Thermal transmittance takes heat loss due to conduction, convection and radiation into account.

Specific Heat: The specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius. The relationship between heat and temperature change is usually expressed in the form shown below where 'c' is the specific heat. The relationship does not apply if a phase change is encountered, because the heat added or removed during a phase change does not change the temperature.

$$Q = c\ m\ \Delta T$$

heat (e.g. added) in Joules (J) — specific heat in J / g°C — mass in grams (g) — change in temperature (e.g. increase in temperature) in degrees Celcius (°C)

Thermal Conductivity: Thermal conductivity refers to the intrinsic ability of a material to transfer or conduct heat. It is one of the three methods of heat transfer, the other two being convection and radiation. Heat transfer processes can be quantified in terms of appropriate rate equations. The rate equation in this heat transfer mode is based on Fourier's law of heat conduction. Thermal conductivity is quantified using the units of W/mK.

There are four factors (k, A, ΔT, d) that affect the rate at which heat is conducted through a material.

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

The letter Q represents the amount of heat transferred in a time t, k is the thermal conductivity constant for the material, A is the cross-sectional area of the material transferring heat, ΔT is the difference in temperature between one side of the material and the other, and d is the thickness of the material.

Material having thermal conductivity k — Area A — T_2 — Q — T_1 — d — $T_2 > T_1$

Source: https://thermtest.com/what-is-thermal-conductivity
https://www.khanacademy.org/science/physics/thermodynamics/specific-heat-and-heat-transfer/a/what-is-thermal-conductivity
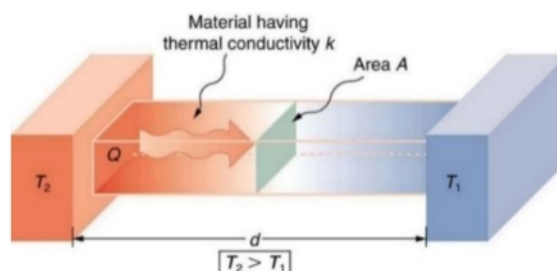
Q.57 Match the application in the field of construction in the Column - I and the respective items in Column - II and select the appropriate option.

Column I	Column II	Options
P. Polytetrafluoroethylene (PTFE) membrane	1. Tendon	(A) P-5, Q-1, R-4, S-3
Q. Isolated compression component inside a network of continuous tensile member	2. TMT	(B) P-4, Q-3, R-1, S-5
R. Cable used for pre-stressed concreting	3. Tensegrity	(C) P-5, Q-3, R-1, S-2
S. Reinforcement bar used in RCC construction	4. TMD	(D) P-3, Q-4, R-2, S-1
	5. Teflon	

Most repeated option:	P-5 Q-3 R-1 S-none
Probable answer:	(C)
Predicted answer was:	Right

PTFE (Polytetrafluoroethylene), a strong, tough, waxy, non-flammable synthetic resin produced by the polymerization of tetrafluoroethylene. Known by such trademarks as Teflon, Fluon, Hostaflon, and Polyflon, PTFE is distinguished by its slippery surface, high melting point, and resistance to attack by almost all chemicals. These properties have made it familiar to consumers as the coating on non-stick cookware; it is also fabricated into industrial products, including bearings, pipe liners, and parts for valves and pumps.

PTFE was discovered serendipitously in 1938 by Roy Plunkett, an American chemist for E.I. du Pont de Nemours & Company (now DuPont Company), who found that a tank of gaseous tetrafluoroethylene refrigerant had polymerized to a white powder. During World War II it was applied as a corrosion-resistant coating to protect metal equipment used in the handling of radioactive material for the Manhattan Project. For more than a decade after the war, PTFE saw little commercial use, owing to difficulties encountered in devising methods for processing the slippery, high-melting material. DuPont released its trademarked Teflon-coated non-stick cookware in 1960.

Tensegrity: Buckminster Fuller coined the term 'tensegrity' by combining two words 'Tensional + Integrity'; it means the integrity of a structure consisting of tension and compression components. His definition of tensegrity structures was 'A tensegrity system is established when a set of discontinuous compressive components interacts with a set of continuous tensile components to define a stable volume in space'. If we apply this definition in broader sense, then the entire universe can be viewed as a tensegrity structure. Planetary systems at a space level or atomic systems at a microstructural level, all of them consist of discontinuous compressed members; for instance, planets (spheres) are connected by gravitational (tensional) forces that symbolize tensile members. It is evident that this definition is too broad, and a more precise one is needed.
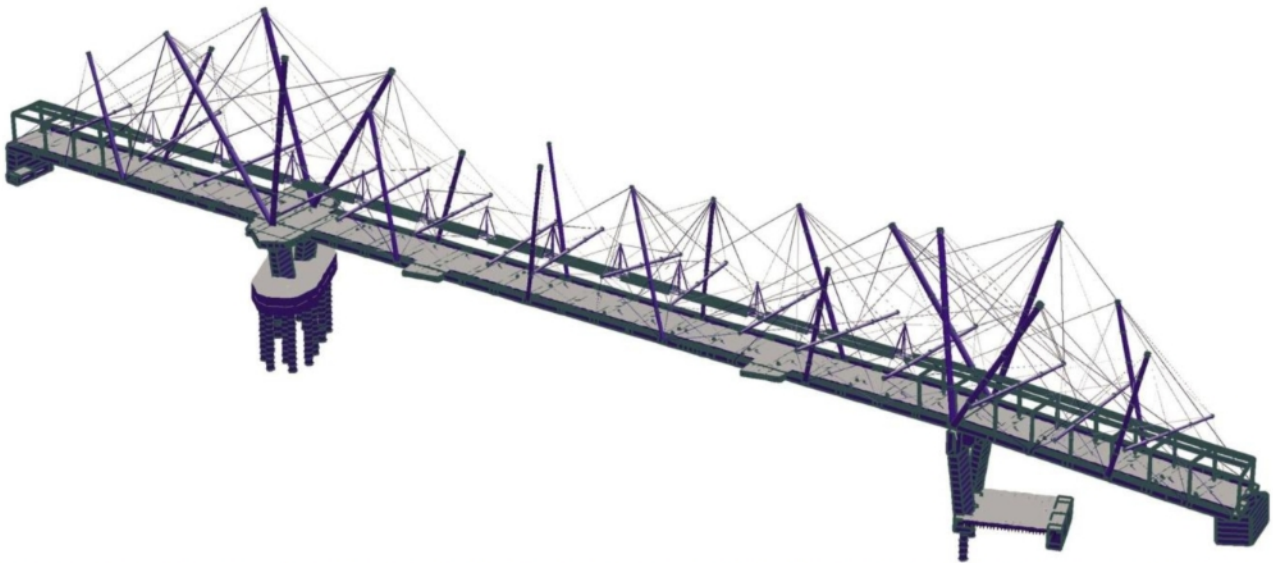

Figure: Kurilpa Bridge in Brisbane is one of the most famous hybrid tensegrity structures that people can use to traverse over a waterway. Its suspended by a series of crane-like pillars that use chords to hold the structure in place.
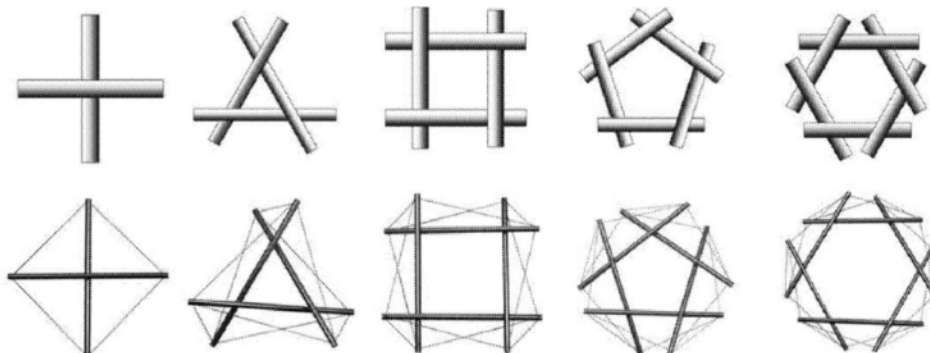

Figure: Basic tensegrity modules and how it's made

https://pdfs.semanticscholar.org/517d/f1669841dfbe3d9316bbaa74104dfbb14638.pdf

Q.61 Match the scientific names of the trees provided in Column - I with the corresponding color of their bloom in Column - II, and select the appropriate option.

Column I	Column II	Options
P. *Cassia fistula*	1. White	(A) P-4, Q-5, R-4, S-1
Q. *Lagerstroemia flos-reginae*	2. Red	(B) P-1, Q-5, R-2, S-3
R. *Cordia sebastena*	3. Blue	(C) P-5, Q-4, R-1, S-3
S. *Plumeria alba*	4. Yellow	(D) P-4, Q-5, R-2, S-1
	5. Mauve	

Most repeated option:	P-4 Q-5 R-2 S-1
Probable answer:	(D)
Predicted answer was:	Right

Cassia fistula	Lagerstroemia flos-reginae	Cordia sebastena	Plumeria alba

Q.62 Match the items in Column - I and their respective location in building/site in Column - II, and select the appropriate option.

Column I	Column II	Options
P. Nahani Trap	1. Between waste water pipe and main house drain	(A) P-4, Q-5, R-2, S-3
Q. Gully Trap	2. Between septic tank and soak pit	(B) P-5, Q-1, R-3, S-2
R. Bottle Trap	3. Junction of house drain and sewer	(C) P-4, Q-1, R-5, S-3
S. Intercepting Trap	4. Bathroom and kitchen floor	(D) P-3, Q-4, R-5, S-2
	5. Below the wash basin	

Most repeated option:	P-4 Q-1 R-5 S-2,3
Probable answer:	(C)
Predicted answer was:	Right

Nahani Trap (Floor Trap)	Gully Trap	Bottle Trap	Intercepting Trap

Q.63 As per the Handbook on Barrier Free and Accessibility, CPWD - 2014, match the design guidelines in Column - I with their appropriate standards in Column - II and select the appropriate option.

Column I	Column II	Options
P. Minimum clear width of ramp	1. 600 mm	(A) P-3, Q-4, R-1, S-5
Q. Maximum height of wash basin (rim) above finished floor level	2. 1500 mm	(B) P-5, Q-3, R-2, S-4
R. Minimum length of grab rail	3. 750 mm	(C) P-5, Q-3, R-1, S-2
S. Minimum clear width for maneuvering space (wheelchair)	4. 900 mm	(D) P-1, Q-4, R-3, S-1
	5. 1800 mm	

Most repeated option:	P-5 Q-3,4 R-1 S-none
Probable answer:	(C)
Predicted answer was:	Right

Tensile strength of Steel: tensile strength is measured by the maximum stress that the steel can withstand while being stretched or pulled before breaking.

Brittleness of Glass: Most glass is made of silica, an amorphous solid in which atoms are arranged haphazardly. Silica glasses are strong, but they are also brittle. The brittleness of normal glass decreases with decreasing density due to the ease of both plastic flow and densification.

Q.58 Match the built forms in Group-I with their descriptions in Group-II

Group I	Group II	Options
P. Agora	1. Custodial precincts	(A) P-1, Q-4, R-3, S-2
Q. Ziggurat	2. Place of Jewish worship	(B) P-4, Q-3, R-1, S-5
R. Mastaba	3. Built in diminishing stages of masonry with buttressed wall	(C) P-4, Q-3, R-5, S-2
S. Synagogue		(D) P-3, Q-1, R-5, S-2
	4. Market place or public square	
	5. Tomb made of mud bricks	

Most repeated option:	P-4　Q-3　R-5　S-2
Probable answer:	(C)
Predicted answer was:	Right

Agora	Ziggurat	Mastaba	Synagogue
Agora, in ancient Greek cities, an open space that served as a meeting ground for various activities of the citizens.	Ziggurat, pyramidal stepped temple tower that is an architectural and religious structure characteristic of the major cities of Mesopotamia (now mainly in Iraq) from approximately 2200 until 500 BCE.	Mastaba, (Arabic: "bench") rectangular superstructure of ancient Egyptian tombs, built of mud brick or, later, stone, with sloping walls and a flat roof. A deep shaft descended to the underground burial chamber.	A synagogue, also called a shul or temple, is a Jewish house of worship. The term "synagogue" is also occasionally used to describe a Samaritan house of worship. Synagogues have a place for prayer and may also have rooms for study, a social hall, offices, and classrooms.

Q.59 Match the landscaping terms in Group-I with their descriptions in Group-II

Group I	Group II	Options
P. Xeriscaping	1. Wide vegetated drain	(A) P-5, Q-3, R-1, S-4
Q. Drip line	2. Tree rings	(B) P-3, Q-5, R-1, S-4
R. Swale	3. Outermost circumference of a tree canopy	(C) P-2, Q-3, R-1, S-5
S. Turf block paver	4. Solution to topsoil erosion and water permeability	(D) P-5, Q-2, R-4, S-1
	5. A little or no irrigation	

Most repeated option:	P-5　Q-3　R-1　S-5
Probable answer:	(A)
Predicted answer was:	Right

Xeriscaping	Drip line	Swale	Turf block paver
Xeriscaping is the practice of designing landscapes to reduce or eliminate the need for irrigation. This means xeriscaped landscapes need little or no water beyond what the natural climate provides.	Drip irrigation involves dripping water onto the soil at very low rate from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile.	Swales are broad, shallow, linear vegetated channels which can store or convey surface water (reducing runoff rates and volumes) and remove pollutants.	Grass block pavers—also known as turf block pavers or grow-through pavers—are an alternative to asphalt, concrete, and traditional pavers. They're made of concrete or recycled plastic with open cells that allow grass to grow through and water to percolate.

Q.60 Match the building configuration characteristics in Group-I with their seismic consequences in Group-II

Group I	Group II	Options
P. Re-entrant corner Q. Floating column R. Irregular storey stiffness S. Gap between adjacent buildings	1. Soft storey 2. Stress concentration at corner 3. Load path discontinuity 4. Vertical asymmetry 5. Pounding	(A) P-3, Q-1, R-2, S-4 (B) P-2, Q-3, R-1, S-5 (C) P-4, Q-3, R-1, S-5 (D) P-3, Q-5, R-2, S-1

Most repeated option:	P-3 Q-3 R-1 S-5
Probable answer:	none
Predicted answer was:	unable to predict

Re-entrant Corners are defined as any inside corner that forms an angle of 180° or less. In a solid object that is subjected to internal or external loads, re-entrant corners create high stress concentrations.

The simplest solution to the re-entrant irregularity is to separate the structure at the notches. Thus, it converts them into smaller blocks of regular configurations. As a result, this eliminates all stress concentration and crack risks.

Figure: Soft storey is a situation when the upper levels of a building is stiffer than the lower storey. This can result in undesirable performance.

Figure: Pounding occurs when the adjacent buildings start vibration out of phase during the seismic activity which causes collision amongst the adjacent buildings.

Figure: Discontinuity in the load transfer path due to floating column leads to poor seismic performance of the structure.

Figure: The fundamental problem of re-entrant corners in a structure is the susceptibility to cracking. After the initiation of a crack, it forms a point of stress concentration on the structure. Further loading heightens the possibility of more cracks and their penetration through the concrete.

Q.61 Match the planning principles in Group-I with their descriptions in Group-II

Group I	Group II	Options
P. Transit oriented development Q. Core periphery theory R. Bid rent theory S. Cluster theory	1. Four stage model of regional development 2. Compact and walkable mixed-use development 3. Geographic concentration of inter-connected institutions 4. Change of land price with relative distance from the CBD 5. Interactive and participatory planning process	(A) P-2, Q-1, R-4, S-3 (B) P-2, Q-1, R-5, S-3 (C) P-4, Q-2, R-5, S-3 (D) P-2, Q-3, R-5, S-4

Most repeated option:	P-2 Q-1 R-5 S-3
Probable answer:	(B)
Predicted answer was:	Wrong

Transit-Oriented Development (TOD) is a type of urban development that maximizes the amount of residential, business and leisure space within walking distance of public transport. In doing so, TOD aims to increase public transport ridership by reducing the use of private cars and by promoting sustainable urban growth.

TOD, is a type of community development that includes a mixture of housing, office, retail and/or other amenities integrated into a walkable neighborhood and located within a half-mile of quality public transportation. It is essential that TOD creates better access to jobs, housing and opportunity for people of all ages and incomes. Successful TOD provides people from all walks of life with convenient, affordable and active lifestyles and creates places where our children can play and our parents can grow old comfortably.

Some of the benefits of TOD include:

- Reduced household driving and thus lowered regional congestion, air pollution and greenhouse gas emissions
- Walkable communities that accommodate more healthy and active lifestyles
- Increased transit ridership and fare revenue
- Potential for added value created through increased and/or sustained property values where transit investments have occurred
- Improved access to jobs and economic opportunity for low-income people and working families
- Expanded mobility choices that reduce dependence on the automobile, reduce transportation costs and free up household income for other purposes

Figure: TOD principles (Source: https://mohua.gov.in)
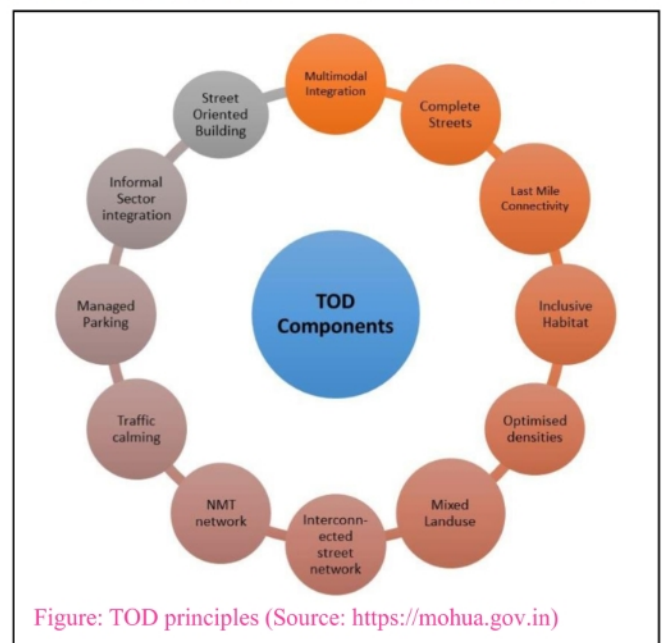
Q.64 Match the Temples in Group-I with their Dynastic period in Group-II

Group I	Group II	Options
P. Brihadeshvara Temple	1. Gupta	(A) P-4, Q-5, R-1, S-2
Q. Kailasanatha Temple	2. Chalukya	(B) P-5, Q-1, R-2, S-3
R. Bhitragaon Temple	3. Lodhi	(C) P-2, Q-5, R-1, S-3
S. Lad Khan Temple	4. Chola	(D) P-4, Q-1, R-2, S-5
	5. Pallava	

Most repeated option:	P-4 Q-5 R-1,2 S-3
Probable answer:	none
Predicted answer was:	unable to predict

Brihadeshvara Temple	Kailasanatha Temple	Bhitragaon Temple	Lad Khan Temple
The Brihadisvara Temple in Thanjavur is a spectacular example of Chola architecture and was built between 1003 and 1010 by the Chola king Rajaraja I.	The Kailasanathar temple, also referred to as the Kailasanatha temple, is a Pallava-era (700 CE) historic Hindu temple in Kanchipuram, Tamil Nadu, India.	Built in the 6th century during the Gupta Empire, it is the oldest remaining terracotta Hindu shrine with a roof and a high Sikhara, though its upper chamber did sustain some damage in the 18th century.	This Chalukya Shiva Temple is located close to the Durga Temple in Aihole. The temple was built by the kings of Chalukya dynasty in 5th century. The temple gets its name from a Muslim ruler Lad Khan who turned the temple as his residence for a short period.

Q.65 Match the Buildings in Group-I with their Architects in Group-II

Group I	Group II	Options
P. Guggenheim Museum, Bilbao	1. Richard Rogers	(A) P-3, Q-4, R-2, S-5
Q. The Shard, London	2. Norman Foster	(B) P-3, Q-4, R-1, S-2
R. Commerz Bank, Frankfurt	3. Frank Gehry	(C) P-2, Q-4, R-1, S-5
S. Heydar Aliyev Centre, Baku	4. Renzo Piano	(D) P-2, Q-5, R-4, S-3
	5. Zaha Hadid	

Most repeated option:	P-3,2 Q-4 R-1 S-5
Probable answer:	none
Predicted answer was:	unable to predict

Guggenheim Museum, Bilbao (1996)	The Shard, London (2012)	Commerz Bank, Frankfurt (1997)	Heydar Aliyev Centre, Baku (2012)
The museum is combined expression of Deconstructivism, Contemporary architecture, Expressionist architecture designed by Frank Gehry.	It is a mix use structure 306 m tall designed by Renzo Piano. The term "The Shard" came about due to the semblance of the building to a shard of glass stabbing out of the ground.	It is triangular in plan and an atrium inside. It is 259 m high structure designed by Norman Foster.	It is a cultural center named after Heydar Aliyev, the first secretary of Soviat Azerbaijan. It is designed by Zaha Hadid.

Section 1: Numerical Questions

Q.1 The minimum road curb length required for parking 10 cars perpendicular to the road is

(A) 15 m   (B) 25 m   (C) 35 m   (D) 40 m

Solution: The minimum road curb length required for parking 10 cars perpendicular to the road is 25m.

Notes:*2.5m wide for 1 car if row parking is provided otherwise 3.0m wide for individual car park.*

Street Parking: if N = Number of cars parked, L = Length of parking bay, then for:

Parallel Parking: L = N

30° Parking: L = 0.58 + 5N

45° Parking: L = 3.54 N + 1.77

60° Parking: L = 2.89N + 2.16

Q.2 Maximum horizontal angle from the speaker in a seating area of a lecture theatre should be

(A) 70°   (B) 90°   (C) 120°   (D) 140°

Q.3 A room measuring 5 m x 3.5 m enclosed by brick wall has a ceiling at 3 m height. The room has a door and a window opening of 1 m x 2 m and 1 m x 1 m respectively. The quantity of plastering required for interior walls (in sqm) is

(A) 46.5   (B) 48   (C) 51   (D) 68.5

Solution: Surface area of 4 interior walls = 2(5+3.5) x 3 = 51sqm

Surface area of door = 1m x 2m = 2sqm

Surface area of window = 1m x 1m = 1sqm

So, net surface area for plastering = 51-2-1= 48 sqm Answer

Q.4 One cubic metre of Ordinary Portland Cement yields a volume of M15 concrete in the range of

(A) 2 to 3 cum   (B) 4 to 5 cum   (C) 7 to 8 cum   (D) 8 to 9 cum

Solution: Nominal Mix Concrete: In the nominal mix concretes the constituents of concrete are measured by volume and the proportions are pre- determine such as 1:8:16, 1:4:8 1;3;6 and 1:2;4 etc. The unit of measurement of cement is a bag of 50 kg having a volume of 0.035 cum. The batch boxes are made with the size 35x25x40cm which corresponds to one bag of cement. Nominal mix concretes 1:5:10, 1:4:8, 1:3:6, 1:2:4 and 1;1.5; 3 roughly correspond to M5, M7.5, M 10, M15 and M20 grades of concrete so far as their compressive strength is concerned.

M15 = 1:2:4 (cement : stone : sand)

So, for 1cum of cement will require 2 cum of sand and 4 cum of coarse aggregate. Total 1+2+4 = 7 cum of concrete will be required. Also note that the volume of concrete is reduced by a factor of 1.54. Therefore, effective volume of the concrete would be

= 7/1.54 = 4.54 cum Answer.

What is M15: It is designation of grades of concrete mix. Letter M refers to the mix and number to specified characteristic compressive strength of 15 cm cube at 28 days expressed in N/square mm. Thus M 15 concrete means a concrete of characteristic strength 15N/square mm. Grades of concrete lower than M 15 shall not be used in reinforced concrete.

Q.5 A site in a map drawn to scale of 1:16000 measures 75 sqcm. The actual area of the site in hectares is

(A) 120   (B) 162   (C) 192   (D) 256

Solution: 75 sqcm = √75cm x √75cm

So, actual area = (√75cmx16000) x (√75cmx16000) = (√75x160m)x (√75x160m) =192 hectares {1hectare=100mx100m}

Q.6 In a construction project schedule, A is the first activity. Activities B and C follow A. Activity D follows B and C. Activity E follows C. Activity F follows D and E.

Activity	A	B	C	D	E	F
Duration (in days)	3	2	5	6	5	3

The critical time to complete the project will be

(A) 14 days   (B) 16 days   (C) 17 days   (D) 20 days

Q.7 The maintenance cost of a building will be Rs. 2 lacs after 10 years. The annual sinking fund required for such maintenance @ 6 % interest per annum will be

(A) Rs. 17,200/-   (B) Rs. 15,200/-   (C) Rs. 13,200/-   (D) Rs. 11,200/-

Solution: Sinking Fund = (Maintenance Cost) / [(1 + r)^n /r]…………………………{r = interest rate, n = no. of years

Sinking Fund = (200000) / [{(1 + 6%)^{10} − 1} /6%]

Sinking Fund = (200000) / [(1 + 0.06)^{10} - 1 /0.06]

Sinking Fund = (200000) / [(1.06)^{10} /0.06] = (200000) / [1.79 -1 /0.06] = (200000) / [0.79/0.06] = 200000 /13.167

Sinking Fund = 15189 Answer

Common Data Questions

Common Data for Questions 8 and 9:

Q.8 A beam of span L is simply supported at two ends. One half span of the beam weighs W and the remaining half span weighs 2W. Maximum shear force in the beam will be

(A) W   (B) 1.25W   (C) 1.75W   (D) 3W

Solution: Be tricky. It can easily be solved by eliminating the options on by one.

The total weight of the beam is 3W. If the weight of the beam is evenly distributed, the shear force at both ends will be 3W/2 = 1.5W

So, option (A) & (D) is eliminated

As the system is not symmetrically loaded, at one end the shear force will be greater than 1.5W. Hence option (C) is correct.

Q.26 As per revised building bye-laws, If the required setbacks are - Front 3 metres, each Side 2 metres and Rear 2 metres, then the maximum total buildable area will
(A) increase by 248 sq. m   (B) increase by 40 sq. m   (C) decrease by 30 sq. m   (D) decrease by 40 sq. m
Solution: New Coverage area will be = (15-3-2)m * (12-2-2)m = 10*8 = 80 sq.m.
So, total buildable area = 80 sq.m.*4 floors = 320 sq.m.
Therefore, 320 - 360 = - 40 sq.m. Answer

Statement for Linked Answer Questions 27 & 28:
An aerial photograph is taken from a plane with a camera lens of focal length 305 mm. The desired scale of the photograph is 1:25,000 and the height of the terrain above mean sea level is 300 metres.

Q.27 The flying height of the plane above mean sea level is
(A) 7,625 (B) 7,925 (C) 8,562 (D) 8,965
Solution: 1/25000 = 0.308/x   => x = 7625
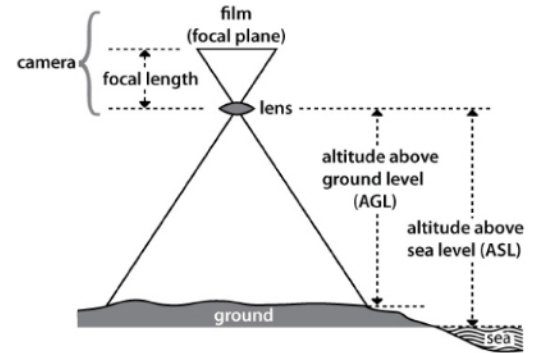So, the flying height of the plane above mean sea level
= 7625 + 300 = 7925 m Answer

Q.28 If the above photograph is taken by a camera lens of focal length 210 mm from the same flying height, then the scale of the photograph will be   (A) 1 : 45,000   (B) 1 : 37,740   (C) 1 : 36,310   (D) 1 : 19,050
Solution: 7650/0.210 = 36310
So, the scale of the photograph will be 1:36310 Answer
Rule [1/scale = focal length/ height]

Statement for Linked Answer Questions 29 & 30:
A beam of cross section 300 mm x 400 mm has overhangs at both ends. The beam has a simple support of 10 metres and an overhang of 5 metres each at both ends and carrying a load of 10 kN on both the free ends.

Q.29 The maximum values of shear force and bending moment in the beam are
(A) 5 kN, 50 kN-m   (B) 20 kN, 80 kN-m   (C) 15 kN, 45 kN-m   (D) 10 kN, 50 kN-m
Solution: Shear force = 10 kN
Bending Moment = 10 kN * 5m = 50 kN-m Answer

Q.30 The maximum values of bending stress and shear stress developed in the beam in N/mm^2 are
(A) 5.15, 0.1   (B) 6.25, 0.125   (C) 7.35, 0.15   (D) 8.45, 0.175
Solution: Bending Stress = (My/I)
Where,
 M= Bending moment = 50 kN-m
 y= distance from neutral axis = 400mm/2 = 200mm
 I= moment of Inertia = $bd^3/12$ = $300*(400)^3/12$ = $16x10^8$ [b= 200mm, d = 400mm]
So, Bending Stress = (My/I)
   ⇨   Bending Stress = $(50 kN\text{-}m*200mm)/16x10^8$ = $(50*1000N*1000mm*200mm)/16x10^8$ = 6.25

Shear stress = 3/2(V/A)
Where,
V = shear forece = 10 kN
A = cross-sectional area = 300x400 = 120000 mm^2
So, Shear stress = 3/2(V/A)
   ⇨   Shear stress = 3/2(10 kN/120000)
   ⇨   Shear stress = 3/2(10*1000N/120000)
   ⇨   Shear stress = 0.125

Scan for Normal Stress, Bending Stress, & Shear Stress

Download PDF (2.5 MB) for Bending Stress & Shear Stress in beams with examples.

Statement for Linked Answer Questions 31 & 32:
An auditorium has a volume of 3000 m^3 with optimum reverberation time of 0.8 seconds.

Q.31 The sound absorption power required in the auditorium in m^2-sabins is approximately (A) 250 (B) 400 (C) 600 (D) 800
Solution: Reverberation time, t = 0.16x (V/A)
[V= volume of room, A = absorption power]
So, 0.8 = 0.16*(3000/A)
   ⇨   A = 600 Answer

Q.32 During a convocation programme in the same auditorium, the absorption power increases by 200 m^2sabins. The reverberation time in seconds will now be
(A) 0.4 (B) 0.6 (C) 0.8 (D) 1.2
Solution: New absorption power = 600 + 200 =800
So, t = 0.16*(V/A) = 0.16*(3000/800) = 0.6 Seconds Answer

Q.33 Ramsar list is related to
(A) Wetlands   (B) Heritage buildings
(C) Seismic zones   (D) Special Economic Zones

Figure: Example of a wetland.

Konark	Madurai	Dilwara	Mamallapuram	Sanchi
The three wheels seen in figure is a part of chariot of the Konark temple.	The Golden Lily Pond (called Potramarai in Tamil) is located inside the Meenakshi Amman Temple, Madurai.	Marble Carved Ceilings Showing Jain Mythology in Dilwara Temple, Mt. Abu	The shore temple at Mamallapuram (Mahabalipuram) consists of two Shiva shrines having vimanas.	The Toranas (Gateways) of the Great Stupa of Sanchi are the oldest freestanding gateways in India.

Q.65 The correct sequence of generic elements in a classical Order arranged from top to bottom is

(A) Architrave > Frieze > Capital > Cornice > Shaft > Pedestal > Base

(B) Architrave > Capital > Cornice > Frieze > Base > Shaft > Pedestal

(C) Cornice > Frieze > Architrave > Capital > Shaft > Base > Pedestal

(D) Cornice > Capital > Frieze > Architrave > Shaft > Pedestal > Base

Q.66 Match the tree forms in Group I with their common examples in Group II.

Group I	Group II	Options
P. Broad	1. False Acacia	(A) P-1, Q-5, R-4, S-2
Q. Tapering	2. Holly	(B) P-1, Q-3, R-4, S-5
R. Conical	3. Lombardy Polar	(C) P-4, Q-1, R-2, S-3
S. Columnar	4. Oak	(D) P-4, Q-5, R-2, S-1
	5. Silver Maple	

Most repeated option:	P-1,4 Q-5 R-4,2 S-none
Probable answer:	(A) or (D)
Predicted answer was:	Wrong
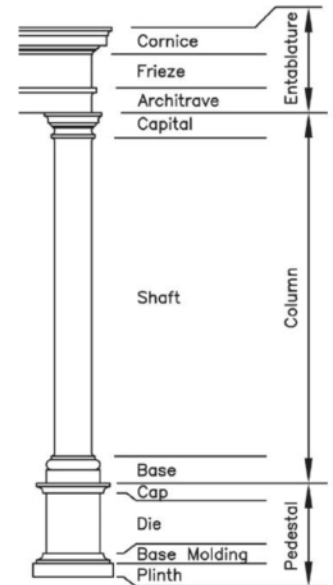
False Acacia (Black Locust)	Holly	Lombardy Polar	Oak	Silver Maple
Robinia pseudoacacia	Ilex aquifolium	Populus nigra	Quercus velutina	Acer saccharinum

Q.67 Match the descriptions in Group I with the elements of Ornamentation in Group II.
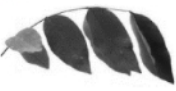
Group I	Group II	Options
P. Painting on a freshly spread moist plaster surface with powdered pigments	1. Chiaroscuro	(A) P-1, Q-2, R-3, S-5
Q. Figure incised into a stone surface or a metal plate yielding an impression in relief	2. Emboss	(B) P-1, Q-5, R-4, S-6
R. Delicate or intricate design on lattice work allowing light through openings	3. Filigree	(C) P-4, Q-2, R-3, S-1
S. Artistic composition consisting of motifs borrowed from different sources	4. Fresco	(D) P-4, Q-5, R-3, S-6
	5. Intaglio	
	6. Pastiche	

Most repeated option:	P-1,4 Q-2,5 R-3,4 S-6
Probable answer:	(B) or (D)
Predicted answer was:	Right

Chiaroscuro: (from Italian chiaro, "light," and scuro, "dark"), technique employed in the visual arts to represent light and shadow as they define three-dimensional objects.

In 1980, the Orangi Pilot Project (OPP), developed a low cost, and locally managed system of sanitation for Orangi, the depressed and crowded settlement, one of Karachi's most blighted districts and its largest *katchi abadi* with a population of 1.2 million. In 1986, OPP started a housing program which followed the same approach as the sanitation program.

Q.73 Match the names of the tree in Group I with the shape of their leaves in Group II

Group I	Group II				Options
P. Ficus religiosta Q. Cassia fistula R. Delonix regia S. Polyalthia longifolia	1.	2.	3.	4.	(A) P-3, Q-2, R-4, S-1 (B) P-4, Q-3, R-1, S-2 (C) P-3, Q-1, R-4, S-2 (D) P-2, Q-1, R-3, S-4

Ficus religiosta
(Peepal)

Cassia fistula
(Amaltas)

Delonix regia
(Gulmohar)

Polyalthia longifolia
(Ashok)

Q.74 Match the Orders of Architecture in Group I with their most appropriate symbolic expression in Group II

Group I	Group II	Options
P. Doric Q. Iconic R. Corinthian S. Composite	1. Floral 2. Most decorative 3. Masculine 4. Feminine	(A) P-3, Q-4, R-1, S-2 (B) P-2, Q-3, R-4, S-1 (C) P-4, Q-1, R-2, S-3 (D) P-1, Q-4, R-3, S-2

Doric	*Ionic*	*Corinthian*	*Composite*	*Tuscan*
* It is called Doric order because it was developed in the western Dorian region of Greece. * Oldest and simplest. * Represents strength and masculinity.	* It is called Ionic order because it was originated in a place called Ionia. * Elegant scroll type capital. * Feminine characteristics.	* It is named after the city of Corinth. * It is decorated with Acanthus leaves. * Not used in Greek world but often used in Roman temples.	* It is called composite because it is composed of Ionic volutes and Corinthian. * It is the late development of the Corinthian.	* It is Roman adaptation of the Doric.

Q.75 Referring to the structure shown in figure below, the maximum Shearing force in the beam is at point

20 kN   18 kN

P   Q   R   S

6m   6m   2m
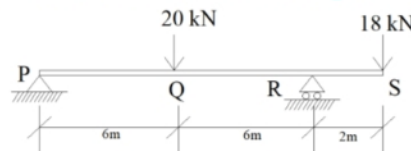
(A) P   (B) Q   (C) R   (D) S

Q.76 Choose the correct set of factors of physical planning to be placed at the vertex of Geddesian Triangle

P. Development
Q. Area
R. Function
S. Node
T. Linkage

(A) P, Q, R   (B) Q, R, S
(C) R, S, T   (D) P, Q, T

WORK

FOLK   PLACE
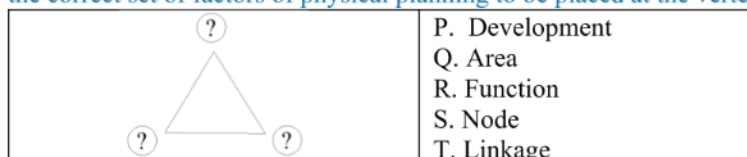
Q.81 Arrange the sequence of events in a Residential site development
P. Levelling and land filling
Q. Trees and plantation
R. Electrification
S. Allotment
T. Provision of roads
U. Provision of water supply, sewerage and drainage
(A) R, S, T, U, P, Q
(B) P, R, S, U, T, Q
(C) Q, P, S, R, T, U
(D) P, T, Q, U, R, S

Figure: (left side), 4-way intersection with total 32 conflict points. (right side), 3-way intersection with total 9 conflict points.

Q.82 Indicate the correct match for items given in Group I with items given in Group II

Group I	Group II	Option
P. Stone	1. Pitting	(A) P-2, Q-4, R-5, S-1
Q. Timber	2. Mottle	(B) P-2, Q-3, R-1, S-6
R. Brick	3. Chalking	(C) P-3, Q-1, R-5, S-2
S. Lime	4. Star shake	(D) P-1, Q-3, R-4, S-2
	5. Unburnt	
	6. Cracking	

Most repeated option:	P-2 Q-3 R-5 S-2
Probable answer:	none
Predicted answer was:	unable to predict

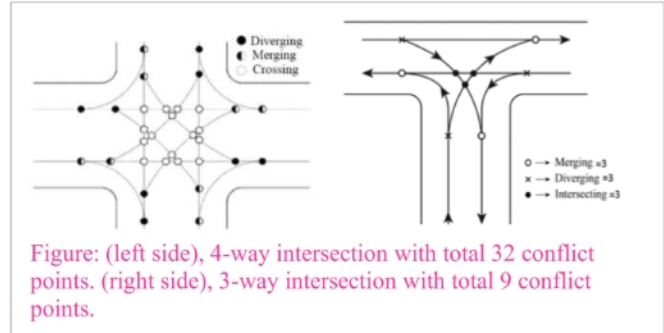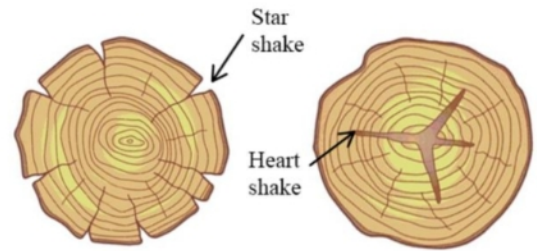Mottle: It is a pattern of irregular marks, spots, streaks, blotches or patches of different shades or colours. In geology, mottle describes the outward appearance of rocks in terms of texture and rock color.

Pitting: If calcium carbonate is present in brick raw material, quicklime will be produced in the kiln. This quicklime, with the help of water, will form hydrated lime and the process expands. Sufficiently large lime particle located near the surface will pop off a piece of brick which will generally create a circular pit. The process is known as lime pitting of bricks.

Q.83 Which is the correct match for items given in Group I with items given in Group II

Group I	Group II	Options
P. Thermal inversion	1. Water repellent	(A) P-2, Q-4, R-1, S-3
Q. Efflorescence	2. Stable airflow	(B) P-2, Q-3, R-4, S-1
R. Hydrophobic surface	3. Lecture Hall	(C) P-1, Q-4, R-3, S-1
S. Psychedelic effect	4. Crystallization	(D) P-5, Q-3, R-1, S-2
	5. Globulation	

Most repeated option:	P-2 Q-4,3 R-1 S-1
Probable answer:	(A)
Predicted answer was:	Right

Efflorescence is a crystalline deposit of salts that can form when water is present in or on brick, concrete, stone, stucco or other building surfaces. Therefore, efflorescence is a deposit of salts, usually white, formed on a surface, the substance having emerged in solution from within either concrete or masonry and subsequently precipitated by evaporation.

Hydrophobic meaning hydro (water), phobic (fear).

Thermal inversion, also called temperature inversion, a reversal of the normal behaviour of temperature in the troposphere (the region of the atmosphere nearest Earth's surface), in which a layer of cool air at the surface is overlain by a layer of warmer air.

Q.84 A general hospital has the following functional areas.
P. Entry   Q. Emergency   R. Out Patient Department
S. In Patient Department   T. Diagnostic Therapeutic Unit   U. Incinerator
V. Mortuary   W. Kitchen & Laundry
Select from the following group of pairs the one you consider as most appropriate designing the hospital.
(A) PR, QW, RS   (B) PR, ST, RT   (C) RT, PU, RV   (D) RV, UV, QR

Q.85 In high-rise building the, walls are built thinner as they get higher. Select the most important pair of factors.
P. Thinner wall has less weight to bear at the top   Q. Thinner walls are suitable for earthquake
R. Thinner walls look beautiful   S. Thinner walls can take electrical conduit pipe easily
T. Thinner walls have moment of inertia
(A) P, R   (B) P, Q   (C) R, S   (D) Q, T

Q.86 In the landscape drains, correlate the drain types with their positive or negative attributes and select the appropriate combinations.

Group I	Group II	Options
P. Open drain	1. Economic	(A) P-1, 2, 4, 6
Q. Swale	2. Easy collection	(B) Q-2, 3, 6, 4
R. French drain	3. Susceptible to clogging	(C) R-1, 2, 5, 6
S. Pipe drain	4. High rate of flow	(D) S-1, 4, 5, 6
	5. Easy maintenance	
	6. Visual scar	

A swale is a gradually sloping drainage channel used to redirect water in a landscape area or garden.

2.2 Match the following (10 x 1 mark = 10 marks)

Group I	Group II
1. Golden Ages of the Great Cities	A. Victor Gruen (4)
2. The Landscape of Roads	B. Fisher Robert M. (8)
3. Design Fundamentals	C. Edmund N Bacon (5)
4. The emerging Urban Pattern	D. Crowe Sylvia (2)
5. Design of Cities	E. Bowra, Sir Maurice (1)
6. Tomorrow: a peaceful path to social reform	F. C.A. Doxiadis (10)
7. New Horizon in Colour	G. Ebenezer Howard (6)
8. Twenty years of Public Housing	H. Robert Gillam Scot (3)
9. Mastering Turbo C	I. Faber Birren (7)
10. Urban Renewal and the Future of the American Cities	J. Stan Kelly-Bootle (9)

2.3 Match the following (5 x 1 mark = 5 marks)

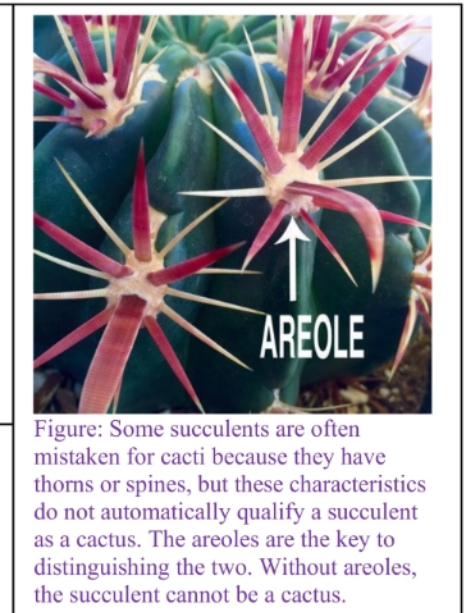| Group I	Group II
1. Calistemon lanceletus	A. Heliodom (5)
2. Isovist	B. Computing (4)
3. Float	C. Landscape (2)
4. Iteration	D. Activity (3)
5. Sunpath	E. Bottle Brush (1)

Q.3 Distinguish between:

1. Turbidity and Color in drinking water

Colour and turbidity are two water quality parameters that detract from the appearance of water, making it unpleasing to drink for aesthetic reasons. Unfortunately, both are common with the district's water supply. Colour is due to an organic material that has dissolved into solution, while turbidity consists of tiny particles suspended in the water column. If a glass of water were left on the counter overnight, in the morning the material causing turbidity would have settled to the bottom of the glass while the colour would remain as before.

Figure: Yucca, Adenium, Faucaria, and Aloe Vera are from the following succulent families: Agavaceae, Apocynaceae, Aizoaceae, and Aloaceae respectively. (Source: cactusway.com)

2. Cactii and Succulent

CACTUS	SUCCULENT
A succulent plant with a thick fleshy stem, which typically bears spines, lacks leaves	A plant with thick fleshy leaves or stems adapted to storing water
Indigenous from Alaska to Chile in the Western Hemisphere	Native to most parts of the world
Areoles are present	Areoles are absent
Leaves are absent	Leaves are present
Grow in desert conditions	Grow in semi-desert conditions
Store water in the stem	Store water in leaves, stem, and roots

Figure: Cacti (left), Succulent (right). Note that All cacti are succulents, but not all succulents are cacti.

Figure: Some succulents are often mistaken for cacti because they have thorns or spines, but these characteristics do not automatically qualify a succulent as a cactus. The areoles are the key to distinguishing the two. Without areoles, the succulent cannot be a cactus.

3. Algae and Algicide

Algae is the name given to a large and diverse group of oxygenic, phototrophic, eukaryotic microorganisms. Algae are eukaryotic, which means they have a nucleus. This differentiates them from *bacteria* and photosynthetic *Cyanobacteria*. They are oxygenic phototrophs, meaning they use light as their energy source for growth and produce oxygen as a byproduct, like plants.
But what distinguishes algae from plants is that algae do not have any tissue differentiation. Plants can differentiate their tissues into roots, trunks, and leaves, all very different tissue types. In contrast, algae are composed of cells that are generally all the same. Despite the differences between plants and algae, many algal species are closely related to plants. But the algae are very diverse. Some algae, like *Euglena*, are closer evolutionarily to single-celled protozoa than to plants. The main unifying characteristic that determines if a species is considered an alga is that all algae contain or have a very recent ancestor that contained *chlorophyll a*. (Alga is singular while algae is plural.)
Algaecide is a chemical treatment for swimming pools, fish ponds, and other water features that kill algae. Chlorine dioxide is a strong oxidizing agent, bactericide, fungicide, algicide, and antiseptic.

4. d-base and LOTUS

dBASE was one of the most successful database management systems for microcomputers. It was the first commercially successful database system for personal computers.

Shrub: These are medium-sized, woody plants taller than herbs and shorter than a tree. Their features include bushy, hard, and woody stems with many branches. Although stems are hard, they are flexible but not fragile. Example: Rose (Rosa Rubiginosa), jasmine (genus Jasminum), lemon (Citrus limon), tulsi (Ocimum tenuiflorum), henna (Lawsonia inermis) etc.

Herb: These are short-sized plants with soft, green, delicate stems without woody tissues. They complete their life cycle within one or two seasons. Generally, they have few branches or are branchless. These can be easily uprooted from the soil. Examples: Tomato (Solanum lycopersicum), wheat (Triticum aestivum), paddy (Oryza sativa), *doob* grass (Cynodon dactylon), bananas (Musa paradisiaca) etc.

Creeper: As the name suggests, creepers are plants that creep on the ground. They have very fragile, long. thin stems that can neither stand erect nor support all their weight. Example: watermelon (Citrullus lanatus), strawberry (Fragaria ananassa), pumpkin (Cucurbita pepo), sweet potato (Ipomoea batatas) etc.

Climber: much more advanced than creepers. Climbers have a very thin, long and weak stem which cannot stand upright, but they can use external support to grow vertically and carry their weight. These types of plants use special structures called tendrils to climb. Example: grapevine (Vitis vinifera), sweet gourd (Lagenaria siceraria), money plant (Epipremnum aureum), jasmine (genus Jasminum), runner beans (Phaseolus coccineus), green peas (Pisum sativum) etc.

SECTION B (50 marks)
PART-1 (Answer any TEN questions. All questions carry equal marks.)

Q.11 Critically examine the architectural works developed by Laurie Baker and its influence in modern architecture in India.

Figure: Centre for Development Studies, is one of Laurie Baker's best campus designs, located in a residential area on the northern outskirts of Thiruvananthapuram. The 10 acre campus stretching across a heavily wooded site houses the Library, Computer center, auditorium, hostels, guesthouses and residential units for the staff.
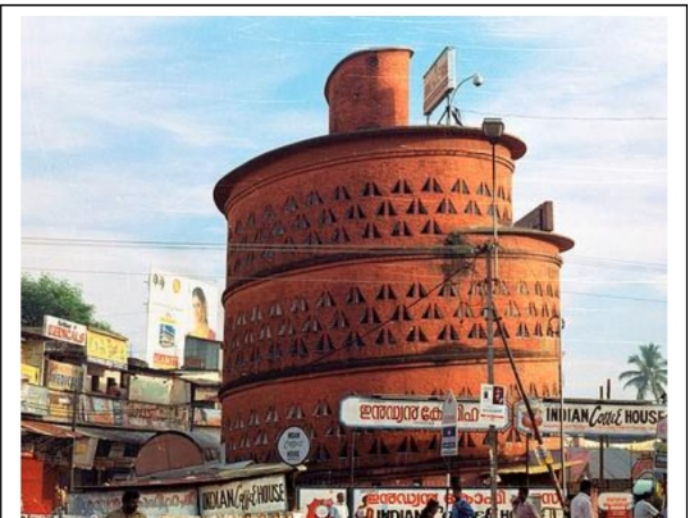

Figure: Indian Coffee House, Thiruvananthapuram. Laurie Baker effectively uses the minimal space availability with a Jali-lit, cylindrical volume and spiral ramp that would facilitate the easy access of the users amidst providing a unique dining experience.

Q.12 Explain with sketches the working of Aqua Privy.
Aqua Privy is essentially a small septic tank located directly below a squatting plate which has a drop pipe extending below the liquid level in the tank to form a simple water seal. To prevent odor, fly and mosquito nuisance in the toilet, the water seal has to be maintained by adding sufficient water per toilet visit to the tank via the drop-pipe to replace any losses. The excreta are deposited directly into the tank where they are decomposed anaerobically similar to a septic tank. A housing or shed is built over the tank. A vent pipe with a fly screen at the top end is attached to the housing. A water-tight tank is desirable to minimize losses. An effluent (overflow) pipe is installed above the level of the drop-pipe.

Q.13 Design a cantilevered R.C. roof slab to carry a live load of 1.5 kN/m^2. The overhang of the slab is 1.2m. Use M 15 grade concrete and Fe 415 grade steel. (Given R=0.658 N/mm^2, j = 0.9, Area of 8 TOR bars = 0.5 cm^2).

Q.14 The average completion time of the following construction activities are given below. As a construction manager for which activities you would like to maintain very strict schedule? Draw the network to justify your decision.

Activity	Average completion time (in weeks)
1-2	11
1-3	14
2-4	6
2-5	16
3-4	7
4-5	3
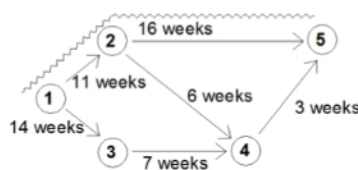
Figure: Aqua Privy.

Solution: 1 > 2 > 5 is the longest path and it should be given prime importance.

Solution:

FBD

SFD

BMD

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

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

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

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

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

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

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

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

Shear:

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

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

Moment:

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

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

$$M_2 = +\frac{FL}{8} \quad @\ x = L/2$$
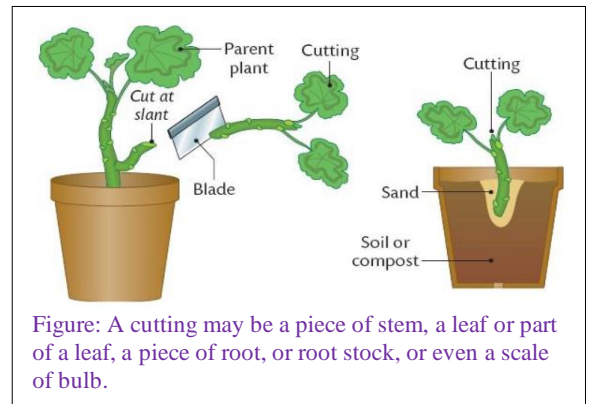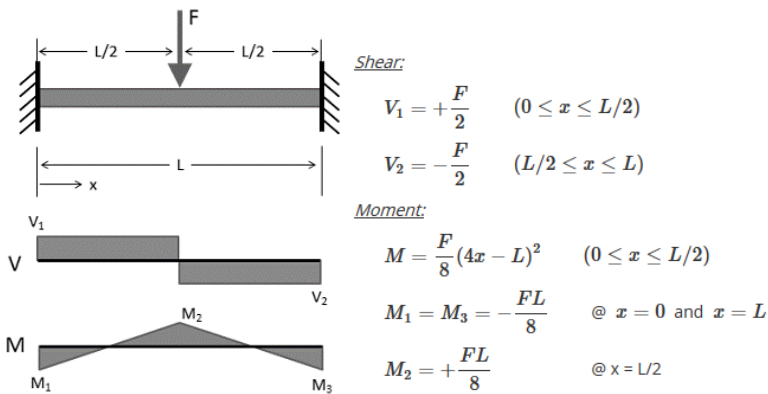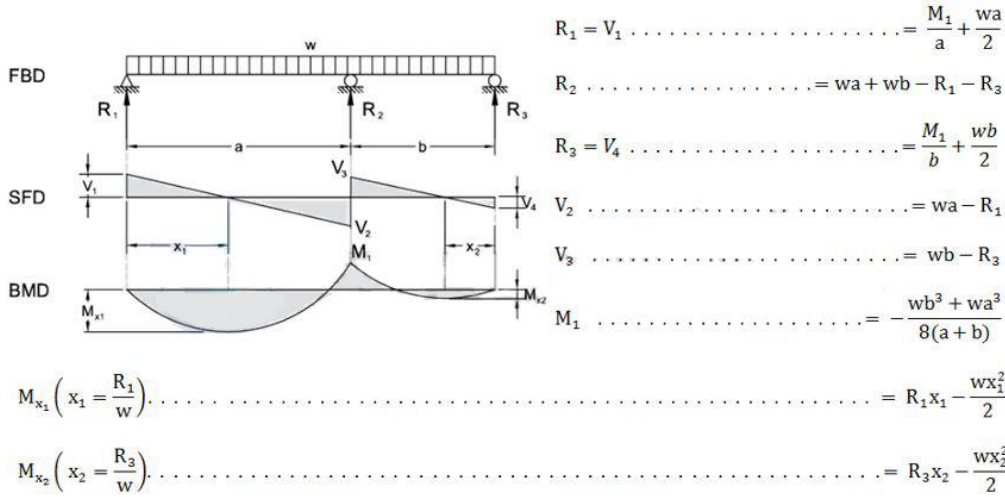
Q.12 Explain the following planting techniques:
12.1 Grafting
12.2 Layering
12.3 Cutting
12.4 Transplantation

Figure: A cutting may be a piece of stem, a leaf or part of a leaf, a piece of root, or root stock, or even a scale of bulb.
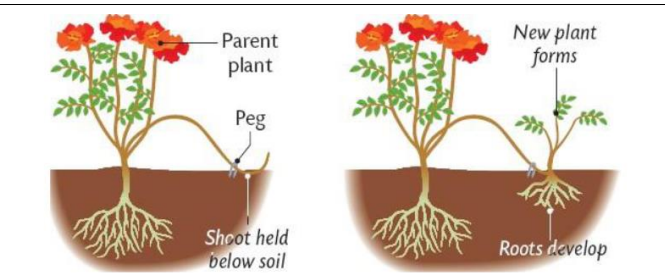
Figure: Layering is the developing of roots on a stem while it is still attached to the parent plant. The rooted stem is then detached or become a new plant growing on its own roots. A layered stem is known as a layer.

Figure: Grafting is an art of joining parts of two independent plants in such a manner that they unite and grow together into single independent plant. The part of graft combination which is to become the upper portion or the shoot system or top of the new plant is termed the scion or cion and the part which is to become the lower portion or the root system is the rootstock or under stock or some time stock. The single plant obtained as a result of union between the stock and scion is termed as Stion.

Figure: "Transplanting" refers to the act of transferring seedlings from containers in the greenhouse (cell trays, flats, pots, etc.) into the garden or field.
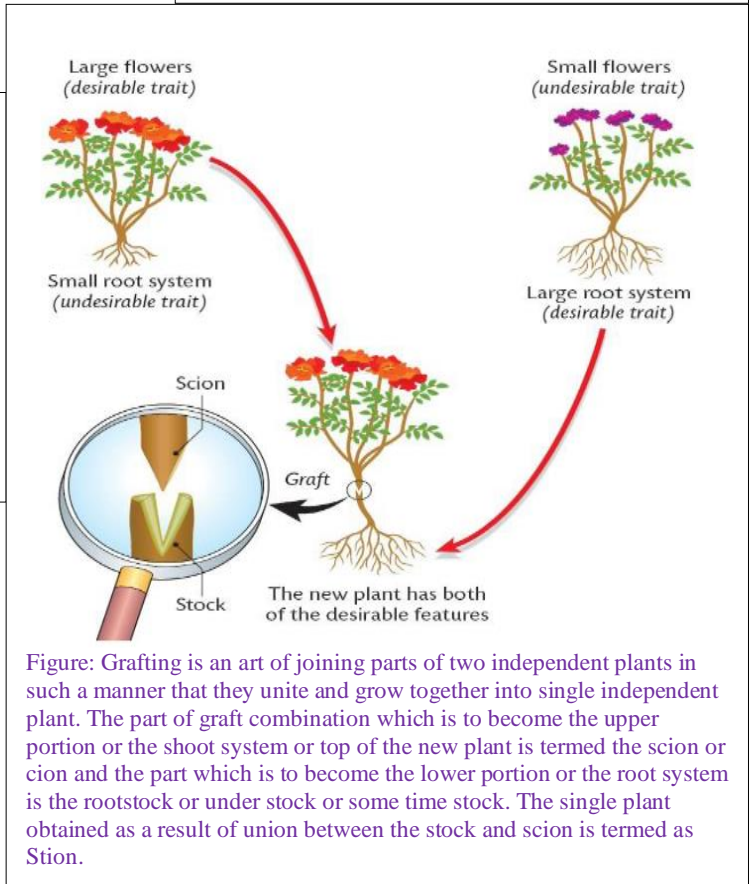
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