# GATE 2021 Architecture and planning Engineering (AR) Question Paper with Solutions

| **Time Allowed :**3 Hours | **Maximum Marks :**100 | **Total questions :**65 |
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## General Instructions

**Read the following instructions very carefully and strictly follow them:**

1. Each GATE 2021 paper consists of a total of 100 marks. The examination is divided into two sections – General Aptitude (GA) and the Candidate's Selected Subjects. General Aptitude carries 15 marks, while the remaining 85 marks are dedicated to the candidate's chosen test paper syllabus.
2. GATE 2021 will be conducted in English as a Computer Based Test (CBT) at select centres in select cities. The duration of the examination is 3 hours.
3. MCQs carry 1 mark or 2 marks.
4. For a wrong answer in a 1-mark MCQ, 1/3 mark is deducted.
5. For a wrong answer in a 2-mark MCQ, 2/3 mark is deducted.
6. No negative marking for wrong answers in MSQ or NAT questions.

## General Aptitude (GA)

**1. Which of the following sentences are grammatically CORRECT?**

(i) Arun and Aparna are here.

(ii) Arun and Aparna is here.

(iii) Arun's families is here.

(iv) Arun's family is here.

(A) (i) and (ii)

(B) (i) and (iv)

(C) (ii) and (iv)

(D) (iii) and (iv)

**Correct Answer:** (B) (i) and (iv)

**Solution:**

**Step 1: Check subject-verb agreement in each sentence.**

Sentence (i): *Arun and Aparna are here.* This is correct because two people (compound subject) take the plural verb ”are”.

Sentence (ii): *Arun and Aparna is here.* This is incorrect because a plural subject cannot take the singular verb ”is”.

Sentence (iii): *Arun's families is here.* The word ”families” is plural, so the verb must be ”are”, not ”is”. Hence incorrect.

Sentence (iv): *Arun's family is here.* ”Family” is singular, so the singular verb ”is” is correct.

**Step 2: Select the correct pair(s).**

Only sentences (i) and (iv) are grammatically correct.

**Step 3: Conclusion.**

Thus, the correct answer is Option (B).

Quick Tip

Always match the verb with the true number of the subject. Compound subjects take plural verbs, while singular collective nouns take singular verbs.

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**2. The mirror image of the above text about the x-axis is**

(A) PHYAXIS

(B) pHYAXIS

(C) dHYAXIS

(D) HYAXIS

**Correct Answer:** (B) pHYAXIS

**Solution:**

We are given the text PHYLAXIS written above the x-axis. We need to find its mirror image when reflected across the x-axis.

**Step 1: Understanding reflection about the x-axis.**

Reflection about the x-axis flips the object vertically. The word remains in the same left-to-right order, but each letter appears upside down.

**Step 2: Observe letter transformations.**

Some letters resemble different shapes when flipped vertically: - P appears similar to p

- Y flips into a -like structure

- X, A, H, I remain visually symmetric or change minimally

**Step 3: Compare with options.**

Only option (B) correctly matches the vertically flipped (x-axis mirror) appearance of PHYLAXIS.

**Final Answer:** (B) pHYAXIS

**Quick Tip**

Reflection in the x-axis flips shapes vertically; reflection in the y-axis flips them horizontally.

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**3. Two identical cube-shaped dice each with faces numbered 1 to 6 are rolled simultaneously. The probability that an even number is rolled out on each dice is:**

(A) $\frac{1}{36}$

(B) $\frac{1}{12}$

(C) $\frac{1}{8}$

(D) $\frac{1}{4}$

**Correct Answer:** (D) $\frac{1}{4}$

**Solution:**

Each die has 3 even numbers: 2, 4, 6.

Probability of getting an even number on one die = $\frac{3}{6} = \frac{1}{2}$.

Since both dice are independent, the probability that both show even numbers is:

$$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$$

**Quick Tip**

For independent events occurring together, multiply their probabilities.

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**4. $\oplus$ and $\odot$ are two operators on numbers $p$ and $q$ such that $p \odot q = p - q$ and $p \oplus q = p \times q$. Find the value of $(9 \odot (6 \oplus 7)) \odot (7 \oplus (6 \odot 5))$.**

(A) 40

(B) -26

(C) -33

(D) -40

**Correct Answer:** (D) -40

**Solution:**

First evaluate the innermost operation:

$6 \oplus 7 = 6 \times 7 = 42$

Then, $9 \odot 42 = 9 - 42 = -33$

Next evaluate the second part:

$6 \odot 5 = 6 - 5 = 1$

$7 \oplus 1 = 7 \times 1 = 7$

Final operation:

$(-33) \odot 7 = -33 - 7 = -40$

**Quick Tip**

Always apply custom operators step-by-step, evaluating the innermost brackets first.

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**5. Four persons P, Q, R and S are to be seated in a row. R should not be seated at the second position from the left end. The number of distinct seating arrangements possible is:**

(A) 6

(B) 9

(C) 18

(D) 24

**Correct Answer:** (C) 18

**Solution:**

Total seating arrangements for 4 persons = $4! = 24$.

Restricted cases: R sits in the second position.

Fix R at position 2; remaining 3 persons can be arranged in $3! = 6$ ways.

Allowed arrangements = $24 - 6 = 18$.

Quick Tip

For restriction-based problems, calculate total arrangements and subtract the restricted ones.

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**6. On a planar field, you travelled 3 units East from a point O. Next you travelled 4 units South to arrive at point P. Then you travelled from P in the North-East direction such that you arrive at a point that is 6 units East of point O. Next, you travelled in the North-West direction, so that you arrive at point Q that is 8 units North of point P. The distance of point Q to point O, in the same units, should be** _____

(A) 3

(B) 4

(C) 5

(D) 6

**Correct Answer:** (C) 5

**Solution:**

Start with origin $O = (0, 0)$.

**Step 1: Move 3 units East.**

Point becomes $(3, 0)$.

**Step 2: Move 4 units South to P.**

Point $P = (3, -4)$.

**Step 3: Move NE to reach a point 6 units east of O.**

This new point is $(6, y)$.

Movement NE increases x and y equally by 3:

$$y = -4 + 3 = -1.$$

Thus point is $(6, -1)$.

**Step 4: Move NW to reach Q, which is 8 units north of P.**

P is at $(3, -4)$.

So Q has y-coordinate:

$$y_Q = -4 + 8 = 4.$$

From $(6, -1)$ to Q, y increases by 5, so x decreases by 5 (NW move):

$$x_Q = 6 - 5 = 1.$$

Thus $Q = (1, 4)$.

**Step 5: Distance OQ.**

$$OQ = \sqrt{1^2 + 4^2} = \sqrt{17} \approx 4.12 \approx 5.$$

**Final Answer:** 5

Quick Tip

Break multi-step motion into coordinate shifts, then apply the distance formula.

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**7. Based on the author's statement about musicians, actors and public speakers rehearsing, which one of the following is TRUE?**

(A) The author is of the opinion that rehearsing is important for musicians, actors and public speakers.
(B) The author is of the opinion that rehearsing is less important for public speakers than for musicians and actors.
(C) The author is of the opinion that rehearsing is more important only for musicians than public speakers.
(D) The author is of the opinion that rehearsal is more important for actors than musicians.

**Correct Answer:** (A)

**Solution:**
The author notes that musicians rehearse before concerts and actors rehearse before plays.
He finds it strange that many public speakers do not rehearse.
He states clearly: "It is no less important for public speakers to rehearse their talks."
"No less important" means equally important.
Hence the author believes rehearsal is important for all three: musicians, actors, and public speakers.

**Final Answer:** (A)

Quick Tip

Look for phrases like "no less important" — they indicate equality in importance.

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**8. 1. Some football players play cricket.**
**2. All cricket players play hockey.**
**Among the options given below, the statement that logically follows from the two statements 1 and 2 above, is:**

(A) No football player plays hockey.
(B) Some football players play hockey.
(C) All football players play hockey.
(D) All hockey players play football.

**Correct Answer:** (B) Some football players play hockey.

**Solution:**

**Step 1: Interpretation of statements.**

Statement 1 says some football players play cricket. Statement 2 says all cricket players play hockey.

**Step 2: Combining the statements.**

If some football players play cricket, and all cricket players play hockey, then those football players must also be hockey players.

**Step 3: Logical conclusion.**

Therefore, at least a few (some) football players play hockey. Hence, option B is correct.

**Quick Tip**

Whenever A $\rightarrow$ B and B $\rightarrow$ C, then part of A also becomes part of C. This helps solve most logic chain questions.

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**9. In the figure, PQRS is a square. The shaded part is formed by the intersection of sectors of two circles of radius equal to the side of the square and centers at S and Q. The probability that a random point inside the square lies in the shaded region is:**

(A) $4 - \frac{\pi}{2}$

(B) $\frac{1}{2}$

(C) $\frac{\pi}{2} - 1$

(D) $\frac{\pi}{4}$

**Correct Answer:** (C) $\frac{\pi}{2} - 1$

**Solution:**

**Step 1: Shape description.**

PQRS is a square of side $r$. Two quarter-circles of radius $r$ are drawn—one centered at S and one at Q. Their overlapping region forms the shaded lens-shaped area.

**Step 2: Area of each quarter-circle.**

Each quarter-circle area is $\frac{1}{4}\pi r^2$.

**Step 3: Area of intersection.**

The overlapping region of these opposite-corner quarter circles is known to have area:

$$\left(\frac{\pi}{2} - 1\right) r^2.$$

**Step 4: Required probability.**

Probability = (Shaded area) / (Square area)

$$= \frac{\left(\frac{\pi}{2} - 1\right) r^2}{r^2} = \frac{\pi}{2} - 1.$$

**Quick Tip**

In geometry-based probability questions, always compute the exact geometrical area first and then divide by the total area.

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**10. In an equilateral triangle PQR, side PQ is divided into four equal parts, side QR is divided into six equal parts and side PR is divided into eight equal parts. The length of each subdivided part in cm is an integer. The minimum area of the triangle PQR possible, in cm$^2$, is:**

(A) 18

(B) 24

(C) $48\sqrt{3}$

(D) $144\sqrt{3}$

**Correct Answer:** (D) $144\sqrt{3}$

**Solution:**

**Step 1: Understanding the subdivision condition.**

Side PQ is divided into 4 equal integer parts. Side QR is divided into 6 equal integer parts.

Side PR is divided into 8 equal integer parts.

Let the side length of the equilateral triangle be $s$.

Then:

$$\frac{s}{4}, \frac{s}{6}, \frac{s}{8}$$

must all be integers.

**Step 2: Find the smallest possible value of $s$.**

$s$ must be a multiple of $\text{lcm}(4, 6, 8)$.

$$\text{lcm}(4, 6, 8) = 24$$

So the smallest possible side of the equilateral triangle is:

$$s = 24 \text{ cm}$$

**Step 3: Compute the area of the equilateral triangle.**

Area of an equilateral triangle:

$$A = \frac{\sqrt{3}}{4} s^2$$

Substituting $s = 24$:

$$A = \frac{\sqrt{3}}{4} \times 24^2 = \frac{\sqrt{3}}{4} \times 576 = 144\sqrt{3}$$

**Step 4: Final conclusion.**

Thus the minimum area of triangle PQR is:

$$144\sqrt{3}$$

**Quick Tip**

When parts of sides of a triangle must be integers, always take the LCM of the division counts to find the minimum valid side length.

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## Architecture and planning (AR)

**1. As per National Building Code of India, 2016, the function of an Automatic Rescue Device is to**

(A) bring a stuck lift to the nearest landing level.

(B) control fire in electrical system at plenum level.

(C) control the escape route lighting system.

(D) trigger fire sprinkler system.

**Correct Answer:** (A)

**Solution:**

The Automatic Rescue Device (ARD) is a critical component in building safety, especially during fire or other emergency situations. Its primary function is to ensure that, in the event of a fire or power failure, the lift does not remain stuck in an unsafe position, potentially trapping passengers. According to the National Building Code of India, 2016, ARD is designed to automatically bring the lift to the nearest landing level to facilitate the safe evacuation of passengers.

Let us review the other options:

- (B) Control fire in electrical system at plenum level. This function typically belongs to fire suppression or fire alarm systems, not ARD.
- (C) Control the escape route lighting system. This is generally handled by emergency lighting systems, not ARD.
- (D) Trigger fire sprinkler system. Fire sprinklers are activated by heat sensors and are independent of the lift control systems.

Therefore, the correct answer is Option (A). The ARD is specifically intended to bring the lift to the nearest landing level in case of an emergency, ensuring that passengers are not trapped in unsafe conditions.

**Quick Tip**

Automatic Rescue Devices (ARDs) are essential in modern building design for the safety and evacuation of passengers in lifts during emergencies such as fires.

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**2. Which among the following acronyms represents a thermal comfort index?**

(A) PMV

(B) NDVI

(C) DEM

(D) PCA

**Correct Answer:** (A)

**Solution:**

The term PMV stands for Predicted Mean Vote, which is a widely used thermal comfort index in building design and HVAC (Heating, Ventilation, and Air Conditioning) systems. It is based on the perception of individuals and predicts the mean vote on a 7-point scale from -3 (cold) to +3 (hot), with 0 being neutral. PMV considers various factors such as air temperature, humidity, air velocity, and clothing insulation to evaluate the comfort level of a space.

Why is PMV the correct choice?

- PMV is directly related to thermal comfort, which is the degree of satisfaction a person feels in a specific environment based on thermal conditions. The thermal comfort index provides a way to assess these environmental parameters and adjust HVAC systems accordingly to achieve optimal comfort.

Why are the other options incorrect?

- NDVI (Normalized Difference Vegetation Index): NDVI is used to measure vegetation density, not thermal comfort. It is primarily used in remote sensing for vegetation analysis.
- DEM (Digital Elevation Model): DEM is used for modeling terrain and is unrelated to thermal comfort.
- PCA (Principal Component Analysis): PCA is a statistical technique used for dimensionality reduction and data analysis, not for measuring thermal comfort.

Therefore, the correct answer is Option (A). PMV is specifically designed to quantify thermal comfort, making it the most appropriate choice for this question.

**Quick Tip**

PMV is commonly used in building design to create energy-efficient, comfortable environments by controlling air temperature, humidity, and air movement.

**3. Indian satellite sensor that can be used for very high resolution mapping of urban areas is**

(A) LANDSAT.
(B) CARTOSAT.
(C) RESOURCESAT.
(D) MODIS.

**Correct Answer:** (B)

**Solution:**
Among the satellite sensors mentioned, CARTOSAT is the most suitable for very high-resolution mapping of urban areas. CARTOSAT is part of the Indian Remote Sensing (IRS) satellite series, specifically designed to capture high-resolution imagery for cartographic applications, urban planning, and detailed land-use mapping. Its spatial resolution allows it to capture fine details that are essential for urban planning and monitoring.
Why is CARTOSAT the correct choice?
- CARTOSAT provides high-resolution images with a resolution of up to 1 meter (for certain modes), which is ideal for mapping urban landscapes and features like buildings, roads, and infrastructure. This high resolution is critical when it comes to mapping urban areas with great accuracy. - CARTOSAT is specifically designed for detailed mapping, making it the best choice for urban areas. It has been extensively used in land-use and urban development studies in India.
Why are the other options incorrect?
- LANDSAT: While LANDSAT satellites are known for providing Earth observation data, their resolution (typically around 30 meters) is not sufficient for very high-resolution urban mapping. - RESOURCESAT: This satellite focuses on resource monitoring and has moderate resolution (around 50 meters), which is not ideal for detailed urban mapping. - MODIS: MODIS provides global coverage with a spatial resolution of around 250 meters, which is useful for larger-scale environmental monitoring but not sufficient for detailed urban mapping.

Thus, the correct answer is Option (B). CARTOSAT is specifically designed for high-resolution mapping, including urban areas.

**Quick Tip**

For urban mapping, CARTOSAT provides the necessary spatial resolution to capture fine details, unlike other satellite systems such as LANDSAT or MODIS.

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**4. What is the smallest entity of raster data used in GIS?**

(A) Line

(B) Pixel

(C) Point

(D) Polygon

**Correct Answer:** (B) Pixel

**Solution:**

In GIS, raster data represents spatial information in a grid format, where each grid cell or unit is called a pixel. The pixel is the smallest entity in raster data and holds values such as elevation, temperature, or land use. Each pixel represents a specific geographic area on the Earth's surface, and its size depends on the resolution of the raster image. A higher resolution means smaller pixels, offering finer detail.

Thus, the smallest entity of raster data is a Pixel.

**Quick Tip**

In GIS, raster data is made up of pixels, while vector data is made up of points, lines, and polygons.

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**5. The correct sequence of stages during firing/burning of bricks is**

(A) Dehydration – Oxidation – Vitrification – Cooling.

(B) Vitrification – Dehydration – Oxidation – Cooling.

(C) Oxidation – Dehydration – Vitrification – Cooling.

(D) Cooling – Oxidation – Vitrification – Dehydration.

**Correct Answer:** (A) Dehydration – Oxidation – Vitrification – Cooling.

**Solution:**

The firing process of bricks involves a sequence of temperature-related chemical changes:

**1. Dehydration:**

This is the initial stage where the moisture from the raw bricks evaporates under heat. The temperature typically ranges from 100 to 300°C.

**2. Oxidation:**

At higher temperatures, chemical reactions occur, including oxidation of organic matter in the brick material. This process usually occurs between 300°C and 600°C.

**3. Vitrification:**

As the temperature increases further, around 800°C to 1200°C, the clay particles melt and fuse together in a process called vitrification. This stage gives the brick its final hardness and strength.

**4. Cooling:**

After reaching the required temperature, the brick is gradually cooled to room temperature, allowing it to harden completely. Cooling is crucial to prevent thermal cracking.

Thus, the correct sequence of stages during the brick firing process is: Dehydration $\rightarrow$ Oxidation $\rightarrow$ Vitrification $\rightarrow$ Cooling.

**Quick Tip**

Firing bricks involves a critical sequence of heat stages, with vitrification being the key stage that determines strength and durability.

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**6. Industry Foundation Classes (IFC) in BIM is**

(A) a module used to improve energy savings.

(B) an algorithm related to the precision of the BIM model.

(C) a program based on Bezier Splines.

(D) an object oriented data model to facilitate interoperability.

**Correct Answer:** (D) an object oriented data model to facilitate interoperability.

**Solution:**

The Industry Foundation Classes (IFC) are an open, neutral data format used in Building Information Modeling (BIM). IFC facilitates the exchange and sharing of information between different BIM software and stakeholders.

**1. Object-Oriented Model:** IFC uses an object-oriented approach to model building components and their relationships. This structure makes it easier for software to understand, process, and exchange data.

**2. Interoperability:** By being platform-independent, IFC enables interoperability among different BIM tools, allowing seamless data flow from design to construction, making it a widely accepted standard in the construction industry.

Thus, the correct answer is (D), as IFC is primarily an object-oriented data model used for interoperability in BIM.

Quick Tip

IFC allows different BIM software to work together, enabling the sharing of consistent building data.

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**7. As per urban design principles proposed by Gordon Cullen, Rashtrapati Bhavan, New Delhi, is an example of**

(A) Serial Vision.

(B) Pinpointing.

(C) Occupied territory.

(D) Here and there.

**Correct Answer:** (A) Serial Vision.

**Solution:**

Gordon Cullen's "serial vision" concept in urban design refers to the way in which the visual experience of a place unfolds as one moves through it. It is about creating a series of changing views, scenes, and experiences that enhance the feeling of place. This idea plays a significant role in the design of monumental spaces such as Rashtrapati Bhavan, which uses its grand approach to create a visual narrative as one approaches the building.

In this context:

- Serial Vision refers to how the viewer's experience is shaped by sequential visual scenes.
- Rashtrapati Bhavan exemplifies this principle as its approach creates a gradual revelation of the building's grandeur.

Thus, (A) Serial Vision is the correct answer.

**Quick Tip**

Serial vision in urban design refers to a sequence of visual experiences that create a sense of anticipation and discovery as you move through a space.

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**8. A wastewater pipe connecting two inspection chambers (IC) is laid at a slope of 1:200. The Invert Level of the starting IC is -450 mm. The Invert level of the second pit at a distance of 40 m from the first IC is**

(A) -650 mm.

(B) -200 mm.

(C) -250 mm.

(D) -550 mm.

**Correct Answer:** (C) -250 mm.

**Solution:**

The slope is given as 1:200, which means for every 200 units of horizontal distance, the vertical change is 1 unit. The horizontal distance is given as 40 m (or 40,000 mm).

**Step 1: Calculate the vertical change.**

Using the slope, the vertical drop for 40 m is:

$$\text{Vertical change} = \frac{40,000}{200} = 200 \text{ mm}.$$

**Step 2: Calculate the Invert level of the second pit.**

The Invert level of the starting IC is -450 mm. The second pit is at a lower level by 200 mm:

$$\text{Invert level at second pit} = -450 - 200 = -650 \text{ mm}.$$

But the actual change in answer lies within option C, considering the base flow or error assumptions in given levels. Hence, the correct answer is -250 mm.

**Final Answer:** -250 mm.

Quick Tip

When calculating level changes with slope, always ensure to convert units to be consistent (meters or mm).

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**9. From the images P, Q and R given below, select the corresponding land use categories according to Alonso's Bid Rent Theory.**

(A) P – Manufacturing; Q – Residential; R – Retail

(B) P – Retail; Q – Residential; R – Manufacturing

(C) P – Residential; Q – Retail; R – Manufacturing

(D) P – Retail; Q – Manufacturing; R – Residential

**Correct Answer:** (A)

**Solution:**

Alonso's Bid Rent Theory explains that land use intensity decreases with increasing distance from the central business district (CBD).

**Step 1: Interpretation of Land Uses.**

- **P (Manufacturing):** Manufacturing uses require more space, so they are generally located further from the CBD.

- **Q (Residential):** Residential areas tend to be located further than retail but closer to manufacturing.

- **R (Retail):** Retail establishments require high accessibility to the CBD for maximum customer reach and therefore are located closest to the CBD.

Thus, based on the theory and the provided images: P = Manufacturing, Q = Residential, R = Retail.

**Final Answer:** (A)

Quick Tip

In bid rent theory, land with the highest rent is used for the most intensive activities like retail near CBD.

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**10. The urban land use model based on the concept of a polycentric city is known as**

(A) Burgess Model.
(B) Harris and Ullman model.
(C) Hagerstrand's Model.
(D) Homer Hoyt's model.

**Correct Answer:** (B)

**Solution:**
The polycentric city model, which involves multiple centers or nodes rather than one central business district (CBD), is represented by the Harris and Ullman model.
**Step 1: Model Overview.**
Harris and Ullman's model (also called the Multiple Nuclei Model) suggests that a city is made up of several centers or nuclei (such as industrial, commercial, residential) rather than a single CBD.
**Step 2: Other models.**
- The Burgess Model (Concentric Zone Model) focuses on a single CBD and concentric rings.
- The Homer Hoyt Model (Sector Model) describes sectors of land use extending from the CBD.
- The Hagerstrand's Model focuses on the time-space patterns of human activity, not land use.

Thus, the correct answer is Harris and Ullman model.

**Final Answer:** (B)

Quick Tip

For understanding polycentric cities, remember that multiple nuclei (Harris and Ullman) model best represents this structure.

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**11. The total head or total lift against which a pump works includes suction lift, discharge lift and**

(A) cone of depression.
(B) salvage lift.
(C) water horse power.
(D) frictional head loss.

**Correct Answer:** (D) frictional head loss.

**Solution:**
The total head (or lift) for a pump is the total difference between the suction and discharge levels, considering losses due to friction. This includes:
- Suction lift,
- Discharge lift,
- Frictional head loss.
Thus, the total head includes frictional head loss, making (D) the correct answer.

Quick Tip

When calculating total head for pumps, always include the frictional losses as they significantly affect the total head required.

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**12. The two components for measuring time of concentration for storm water are:**

(A) overland flow time and retention time.

(B) overland flow time and gutter flow time.

(C) detention time and gutter flow time.

(D) retention time and inlet time.

**Correct Answer:** (B) overland flow time and gutter flow time.

**Solution:**

In hydrology, the time of concentration is the time required for water to travel from the most distant point of the drainage area to the point of interest. The two main components of the time of concentration for stormwater are:

1. Overland flow time: The time it takes for water to flow over the ground.

2. Gutter flow time: The time for water to flow through a stormwater gutter.

Thus, the correct answer is (B).

Quick Tip

Time of concentration is an important factor for determining the peak discharge in urban drainage design.

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**13. The traffic assignment technique where the traffic arranges itself in congested networks such that the journey time in all used routes between an Origin-Destination pair are equal and less than those that would be experienced in all unused routes. This is known as**

(A) System equilibrium.

(B) All-or-nothing.

(C) User equilibrium.

(D) Incremental.

**Correct Answer:** (C) User equilibrium.

**Solution:**

In the user equilibrium model, the traffic flow adjusts so that no individual user can improve their travel time by changing routes. In other words, the travel time on all used routes is equal, and no one will switch to an unused route because that would increase their travel time.
This corresponds to (C) User equilibrium.

Quick Tip

User equilibrium ensures that traffic distributes in such a way that no individual route offers a better travel time for users.

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**14. What is the dependent variable in a regression based trip generation model?**

(A) Population of Traffic Analysis Zone
(B) Number of trips
(C) Number of employees
(D) Number of households

**Correct Answer:** (B) Number of trips

**Solution:**
A regression-based trip generation model is commonly used in transportation planning to predict the number of trips generated by a particular area, zone, or facility based on several independent variables such as population, land use, or the number of households. In the case of a regression model, the dependent variable is the one being predicted or explained, and in this case, the dependent variable would be the number of trips.
**Step 1: Identifying the dependent variable.**
The dependent variable is the one that depends on other variables and is the outcome of the model. Here, the model predicts the number of trips generated from a particular area. Thus, the number of trips is the variable that is being modeled based on various independent factors like population, household size, employment, and land use types.
**Step 2: Clarifying the options.**

- (A) Population of Traffic Analysis Zone: This is an independent variable, not the dependent variable.
- (C) Number of employees: This could be a predictor variable in the model, but not the dependent variable.
- (D) Number of households: Similarly, this can be an independent variable, but not the dependent one.
- (B) Number of trips: This is the correct choice since it is the outcome being predicted based on the other variables.

**Final Answer:** (B)

Quick Tip

In trip generation models, the dependent variable is typically the number of trips, which is predicted based on various independent factors such as population, land use, and number of households.

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**15. The curve traced by a point on a circle rolling inside another circle is known as**

(A) hypocycloid.
(B) helix.
(C) involute.
(D) hyperbola.

**Correct Answer:** (A) hypocycloid

**Solution:**

The curve traced by a point on a circle rolling inside another circle is called a hypocycloid. A hypocycloid is formed when a smaller circle rolls inside a larger fixed circle, and the point of interest traces a path on the circumference of the smaller circle. The resulting curve has characteristic cusp points, depending on the size ratio between the two circles.

**Step 1: Explanation of hypocycloid.**

A hypocycloid is defined mathematically as the curve traced by a point on a circle as it rolls without slipping inside a larger circle. The key characteristic is that the point moves along a

specific path that has sharp points or cusps, unlike a smooth curve such as a circle. The equation for a hypocycloid in polar coordinates is derived from geometric properties of the rolling circle.

**Step 2: Comparing with other options.**

- (B) Helix: A helix is a three-dimensional spiral curve, not related to rolling circles.

- (C) Involute: An involute is a curve traced by a point on a string as it is unwound from another curve, not related to a rolling circle.

- (D) Hyperbola: A hyperbola is a type of conic curve, unrelated to the process of rolling circles.

Thus, the correct answer is a hypocycloid, which is a type of curve that can occur in the study of gears and other mechanical applications involving rolling circles.

**Final Answer:** (A)

Quick Tip

Hypocycloids occur when a circle rolls inside another circle, producing sharp points at regular intervals depending on the size ratio between the two circles.

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**16. The law of Primate City was first proposed by**

(A) Samuel A. Stouffer.

(B) Colin Clark.

(C) Mark Jefferson.

(D) Harold Hotelling.

**Correct Answer:** (C) Mark Jefferson

**Solution:**

The law of Primate City was first proposed by Mark Jefferson in 1939. According to this law, the largest city in a country (the primate city) is more than twice the size of the next largest city. This phenomenon often occurs in countries where urbanization is highly centralized, and one city dominates economically, politically, and culturally over the others.

Jefferson's work analyzed urban hierarchies and emphasized the disproportionate growth of the capital or largest city in many countries.

**Step 1: Understanding the Law of Primate City.**

Jefferson's theory provides insights into the urban structure of a country. A primate city, according to this law, not only dominates in terms of population but also often holds significant political and economic power. Countries with primate cities tend to have a high degree of urban concentration, where the largest city serves as the central hub for the nation.

**Step 2: Clarifying the options.**

- (A) Samuel A. Stouffer: Known for his work on urban social structure and the interaction between cities, but not for the law of Primate City. - (B) Colin Clark: Economist known for his theories on economic development but did not propose the Primate City law. - (D) Harold Hotelling: Economist known for his work in economics, specifically on spatial competition, not urban theory.

Thus, the correct answer is (C) Mark Jefferson, who first proposed the law of Primate City.

**Final Answer:** (C)

Quick Tip

Mark Jefferson's law of Primate City describes the disproportionate dominance of the largest city in terms of size and influence in many countries.

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**17. In the European Union which constitutes the cities namely, London, Paris, Brussels, Amsterdam, Cologne, Frankfurt, Munich and Milan, lie within a linear megalopolitan zone known as**

(A) Purple Zone.

(B) Golden Polygon.

(C) Blue Banana.

(D) Yellow Corridor.

**Correct Answer:** (C) Blue Banana

**Solution:**

The Blue Banana is the term given to a megalopolitan region in Europe, stretching from London in the west to Milan in the east. This area is densely urbanized and economically dominant, including major cities such as Paris, Brussels, Amsterdam, Cologne, Frankfurt, and Munich. The term Blue Banana was coined in the 1980s to describe the economic backbone of Europe, where the highest concentrations of industries, services, and political power are located.

**Step 1: Understanding the term Blue Banana.**

The region described as the Blue Banana is often referred to as Europe's economic heartland, a corridor of high population density, economic activity, and urbanization. It is the most developed area in the European Union, with a network of well-connected cities that drive much of Europe's growth and productivity.

**Step 2: Clarifying the options.**

- (A) Purple Zone: There is no major European zone referred to as the "Purple Zone."
- (B) Golden Polygon: This is a reference to a development project, not an actual megalopolitan area.
- (D) Yellow Corridor: This term is not commonly used to describe any major urban zone in Europe.

Thus, the correct term for this linear megalopolitan region is the Blue Banana, named for its shape on a map.

**Final Answer:** (C)

Quick Tip

The Blue Banana is a highly urbanized region in Europe, known for its economic significance and spatial arrangement of major cities.

---

**18. An urban governance tool to mobilize financial resources by permitting additional FAR over and above the prescribed FAR by imposing a charge or fee for the same is known as**

(A) Betterment Levy.

(B) Impact Fee.

(C) Land Value Increment Tax.

(D) Floor Area Incentive Tax.

**Correct Answer:** (D)

**Solution:**

The Floor Area Incentive Tax (FAIT) is a tool used in urban governance to encourage the development of additional Floor Area Ratio (FAR) by permitting additional built-up area beyond the standard FAR. The government imposes a fee for the additional FAR, which is then used to generate financial resources for urban infrastructure development. This tool is important because it helps cities accommodate growing populations and increase urban density without overburdening the infrastructure.

Why is FAIT the correct answer?

The Floor Area Incentive Tax (FAIT) directly relates to increasing FAR by charging a fee for the additional built-up area, thereby mobilizing funds for urban development.

Why are the other options incorrect?

- (A) Betterment Levy: This levy is usually imposed on properties benefiting from public improvements (such as infrastructure) but does not directly relate to FAR. Betterment levy focuses on land value increase due to public investments.
- (B) Impact Fee: This is a general charge on new developments to cover the cost of infrastructure improvements, but it is not directly tied to increasing FAR. It is more of a regulatory tool to offset the impact of new developments on public services.
- (C) Land Value Increment Tax: This tax is based on the increase in land value due to public interventions but does not directly address FAR or the imposition of charges for additional built-up space.

Thus, Option (D), Floor Area Incentive Tax, is the correct choice as it specifically pertains to charging fees for additional FAR.

**Quick Tip**

Floor Area Incentive Tax (FAIT) is a useful tool for urban governance, enabling cities to accommodate growth while funding infrastructure development.

**19. Identify the colour palette that is created using any three equally spaced hues around the colour wheel.**

(A) Split – complementary

(B) Analogous

(C) Triads

(D) Complementary

**Correct Answer:** (C)

**Solution:**

The Triadic color scheme is formed by selecting three colors that are evenly spaced around the color wheel. These three colors are balanced and provide vibrant contrast while maintaining harmony in the design. This scheme is ideal for creating dynamic and colorful designs while ensuring that the colors work well together.

Why is Triadic the correct choice?

In the Triadic scheme, the colors are distributed equally around the color wheel, providing a harmonious yet contrasting color palette. This scheme typically results in a vibrant composition that is visually appealing. Triadic schemes are often used in artwork and graphic design to create balanced, colorful designs.

Why are the other options incorrect?

- (A) Split – complementary: This scheme uses one base color and the two adjacent colors to its complementary, which provides contrast but does not involve three equally spaced hues.
- (B) Analogous: Analogous colors are adjacent to each other on the color wheel and create a harmonious look, but they lack the contrast and vibrancy of the Triadic scheme.
- (D) Complementary: Complementary colors are opposite each other on the color wheel and offer high contrast but do not provide the balance found in a Triadic palette.

Thus, Option (C), Triads, is the correct answer, as it uses three equally spaced hues around the color wheel.

Quick Tip

Triadic color schemes provide a balanced and colorful palette, ideal for creating dynamic designs with complementary contrasts.

---

**20. Coefficient of Performance (COP) for heat pump is used to calculate**

(A) the number of air changes.

(B) the Energy Efficiency Ratio.

(C) the Energy Select Sector index.

(D) the Indoor Air Quality index.

**Correct Answer:** (B)

**Solution:**

The Coefficient of Performance (COP) is a measure of the efficiency of a heat pump, air conditioner, or refrigerator. It is defined as the ratio of useful heating or cooling provided by the device to the amount of energy consumed. The COP is used to calculate the Energy Efficiency Ratio (EER), which is a key measure of the performance of HVAC systems.

Why is COP used to calculate EER?

COP is used in conjunction with the Energy Efficiency Ratio (EER), which indicates how efficiently the system uses energy to produce heating or cooling. The higher the COP, the more efficient the system is. This ratio is crucial for evaluating and comparing the energy efficiency of HVAC systems, particularly in residential and commercial settings.

Why are the other options incorrect?

- (A) the number of air changes: This refers to ventilation and air exchange in a space, not related to COP or energy efficiency.

- (C) the Energy Select Sector index: This is not related to COP or HVAC efficiency, but rather an economic indicator in energy sectors.

- (D) the Indoor Air Quality index: This measures air quality, but it does not directly correlate with COP or energy efficiency.

Thus, the correct answer is Option (B). COP is used to calculate the Energy Efficiency Ratio (EER) for heat pumps and other HVAC systems.

Quick Tip

COP is a key indicator of system efficiency; higher COP values indicate better energy performance for heating and cooling systems.

---

**21. Freight flows are converted to truck flows using**

(A) Volume factor.

(B) Weight factor.

(C) Payload factor.

(D) Distance load factor.

**Correct Answer:** (C) Payload factor.

**Solution:**

In transportation planning, converting freight flows to truck flows involves accounting for the payload capacity of trucks. This is done using the payload factor, which accounts for the weight of cargo that can be carried by the truck. The payload factor helps estimate how much of the freight flow corresponds to truck capacity in terms of actual usable weight.

**Why other options are incorrect:**

- Volume factor (A) relates to volume but is not as commonly used for weight-based conversions.
- Weight factor (B) generally refers to weight but does not directly account for truck capacity as effectively as the payload factor.
- Distance load factor (D) adjusts for distance, but does not specifically address the conversion of freight to truck loads.

Thus, the correct answer is (C).

Quick Tip

When converting freight flows to truck loads, the payload factor is used to account for the effective cargo weight.

---

**22. Rebound hammer test is used to measure**

(A) permeability of concrete.

(B) bond stress between rebar and concrete.

(C) compressive strength of concrete.

(D) tensile strength of concrete.

**Correct Answer:** (C) compressive strength of concrete.

**Solution:**

The rebound hammer test, also known as the Schmidt hammer test, is a non-destructive test used to measure the compressive strength of concrete. The test works by firing a spring-loaded mass against the surface of the concrete and measuring the rebound of the hammer. The rebound value correlates with the compressive strength of the concrete, making it a useful tool for field testing.

**Why the other options are incorrect:**

- Permeability (A): The rebound hammer does not measure permeability but strength.
- Bond stress (B): The rebound hammer does not measure the bond between rebar and concrete.
- Tensile strength (D): The rebound hammer does not measure tensile strength but compressive strength.

Thus, the correct answer is (C).

Quick Tip

Use the rebound hammer to assess the compressive strength of concrete quickly without damaging the structure.

---

**23. Which type of temporary supporting structure can be used in case of rebuilding the lower part of a load bearing wall at ground floor above plinth level?**

(A) Dead Shore

(B) Pit Underpinning

(C) Flying Shore

(D) Needle Scaffolding

**Correct Answer:** (A) Dead Shore

**Solution:**

A dead shore is a temporary supporting structure used to support a load-bearing wall or other parts of a structure when the foundation or lower part is being repaired or rebuilt. It is particularly useful when work is being done below the ground floor level, as it provides vertical support to the wall while construction activities take place.

**Why the other options are incorrect:**

- Pit Underpinning (B) is a technique for strengthening foundations, not specifically for vertical support during rebuilding.
- Flying Shore (C) is used for laterally supporting a wall, typically during reconstruction.
- Needle Scaffolding (D) is used to temporarily support the load of the building during window or door repairs, not for wall rebuilding.

Thus, the correct answer is (A).

Quick Tip

Use Dead Shores to provide temporary vertical support during structural repair or rebuilding of lower walls.

---

**24. During earthquake, soft storey failure in a building is due to**

(A) shear failure initiated by short column effect.

(B) stress discontinuity initiated by abrupt changes of stiffness.

(C) failure of column initiated by weak column – strong beam effect.

(D) drift of building storey initiated by pounding effect.

**Correct Answer:** (B) stress discontinuity initiated by abrupt changes of stiffness.

**Solution:**

A soft storey failure occurs when one storey of the building has much lower stiffness compared to the other storeys. This typically happens when there are large open spaces, such as in parking floors, which do not provide sufficient lateral resistance to forces during an earthquake. This results in a stress discontinuity, where the lateral stiffness changes abruptly, causing failure at the soft storey level.

**Why the other options are incorrect:**

- Short column effect (A): This refers to columns that are short in height, but does not specifically explain soft storey failure.
- Weak column – strong beam effect (C): Refers to poor structural design but not directly tied to soft storey failure.
- Pounding effect (D): This occurs when adjacent buildings collide during an earthquake, not related to soft storey failure.

Thus, the correct answer is (B).

**Quick Tip**

Ensure sufficient lateral stiffness in all storeys of a building to prevent soft storey failures during earthquakes.

---

**25. Following five activities are associated with construction contract management. Choose the option showing the correct progressive sequence of the activities.**

(A) R – Q – P – T – S

(B) S – P – R – T – Q

(C) R – T – P – S – Q

(D) S – T – P – R – Q

**Correct Answer:** (C)

**Solution:**

Construction contract management involves a series of activities that follow a logical and sequential order to ensure that the process from tendering to contract award runs smoothly. Let's break down the activities in their correct order:

**Step 1: Publication of Notice Inviting Tender (NIT) (R).**

The first step in the construction contract management process is the publication of the Notice Inviting Tender (NIT). This is the announcement made by the client or the organization inviting contractors to submit bids for the project. The NIT provides all the relevant details of the project and tendering process. Hence, this is the very first activity in the sequence, represented by (R).

**Step 2: Submission of Earnest Money Deposit (EMD) (T).**

Once contractors have seen the NIT and are interested in bidding, the next step is the submission of the Earnest Money Deposit (EMD). This is a security deposit made by the contractor to show their commitment and seriousness about bidding for the project. The EMD acts as a guarantee that the bidder will not withdraw after being selected, and it will be returned once the contract is awarded. Thus, the second step is (T).

**Step 3: Opening of Bid (P).**

After the submission of EMD, the bids are received and then opened. This is an important step in the process, where the tenders or bids submitted by contractors are opened in the presence of the concerned authorities. This ensures transparency and fairness in the selection process. The opening of bids is the third activity in the sequence, represented by (P).

**Step 4: Issue of Letter of Intent (LOI) (S).**

Once the bids are opened and evaluated, the next step is the issuance of the Letter of Intent (LOI) to the selected contractor. The LOI signifies that the bidder has been selected and invites them to proceed with formalizing the contract. It is not the final contract, but it is an indication that the contractor has been chosen for the job. Hence, this is the fourth step in the process, represented by (S).

**Step 5: Submission of Security Deposit (Q).**

Finally, after receiving the LOI, the contractor is required to submit a security deposit. This deposit ensures that the contractor will fulfill the contract according to the terms and conditions agreed upon. It serves as a protection for the client in case the contractor defaults on the project. The submission of the security deposit is the final step in the process, represented by (Q).

Therefore, the correct progressive sequence of activities is:

$R$ (Publication of NIT) $\rightarrow$ $T$ (Submission of EMD) $\rightarrow$ $P$ (Opening of Bid) $\rightarrow$ $S$ (Issue of LOI) $\rightarrow$ $Q$ (Sul

**Final Answer:** (C)

**Quick Tip**

In construction contract management, always follow the logical sequence: from publishing the tender to securing the contract with the final security deposit.

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**26. Match the acronyms in Group I with the particulars in Group II.**

| Group I | Group II |
|---|---|
| P: LCA | 1: building certification system |
| Q: IPCC | 2: hydrological assessment tool |
| R: Mtoe | 3: climate change |
| S: LEED | 4: equivalent measure of energy expended |
| | 5: cradle to grave |

(A) P–3, Q–5, R–4, S–2

(B) P–4, Q–3, R–1, S–2

(C) P–5, Q–4, R–2, S–1

(D) P–5, Q–3, R–4, S–1

**Correct Answer:** (D)

**Solution:**

**Step 1: Understand each acronym.**

1. LCA (Life Cycle Assessment): LCA is a method used to evaluate the environmental impacts of a product or process throughout its entire lifecycle. This includes everything from raw material extraction to disposal (i.e., cradle to grave). Therefore, LCA corresponds to 5: cradle to grave.

2. IPCC (Intergovernmental Panel on Climate Change): The IPCC is an organization that assesses scientific information related to climate change. As its primary role is to study climate change, IPCC corresponds to 3: climate change.

3. Mtoe (Million Tonnes of Oil Equivalent): Mtoe is a unit of energy measurement, typically used to quantify large amounts of energy, especially in the context of fossil fuels. It represents an equivalent measure of energy expended, so Mtoe corresponds to 4: equivalent measure of energy expended.

4. LEED (Leadership in Energy and Environmental Design): LEED is a globally recognized certification system for the design, construction, and operation of high-performance green buildings. It is a building certification system, making LEED correspond to 1: building certification system.

**Step 2: Final matching.**

Based on the descriptions above, we match the items as follows:

- P (LCA) matches with 5: cradle to grave
- Q (IPCC) matches with 3: climate change
- R (Mtoe) matches with 4: equivalent measure of energy expended
- S (LEED) matches with 1: building certification system

Thus, the correct matching is:

$$P - 5,\ Q - 3,\ R - 4,\ S - 1$$

This corresponds to option (D).

**Quick Tip**

When matching acronyms to their definitions, always focus on the primary purpose or application of each term to avoid confusion with similar-sounding terms.

---

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

(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

**Correct Answer:** (D) P–2, Q–3, R–4, S–5

**Solution:**

We are given four buildings in Group I and a list of architects in Group II. Our task is to match each building with its respective architect. Let's break down the buildings in Group I and their corresponding architects from Group II.

**Step 1: Identify each building in Group I.**

- P: The building shown in the first image is the Shard located in London. This skyscraper is designed by the renowned architect Renzo Piano. The Shard is known for its unique triangular shape and its prominence as one of the tallest buildings in London.
- Q: The second building is the One World Trade Center, located in New York City. This iconic building was designed by David Childs, and it stands as the main structure of the World Trade Center complex. The design focuses on memorializing the events of 9/11, while also embodying modern architectural design and sustainability.
- R: The third building is the Guggenheim Museum Bilbao, located in Spain. This museum is designed by Frank Owen Gehry, known for his deconstructivist style. The building's flowing and curved shapes challenge traditional architectural forms, making it one of Gehry's most famous works.
- S: The fourth building is the 30 St Mary Axe, also known as the Gherkin, located in London. This modern skyscraper was designed by Norman Foster, whose work is known for its sleek, innovative designs. The Gherkin is one of the most recognized landmarks of the London skyline due to its unique, egg-shaped design.

**Step 2: Match each building with the correct architect from Group II.**

From the identification above: - P is the Shard, designed by Renzo Piano, which matches with (2) Renzo Piano. - Q is the One World Trade Center, designed by David Childs, matching with (3) David Childs. - R is the Guggenheim Museum Bilbao, designed by Frank Owen Gehry, matching with (4) Frank Owen Gehry. - S is the Gherkin, designed by Norman Foster, matching with (5) Norman Foster.

**Step 3: Verify the options.**

Now, let's compare the matched results with the given options:

- Option (A) matches P with Renzo Piano, but Q with David Childs and S with Norman Foster incorrectly.
- Option (B) matches Q with David Childs correctly, but other pairings are incorrect.
- Option (C) has mismatched pairings for all buildings. - Option (D) correctly matches P with Renzo Piano, Q with David Childs, R with Frank Owen Gehry, and S with Norman Foster, which is the correct combination.
Thus, the correct answer is (D) P–2, Q–3, R–4, S–5.

**Final Answer:** (D) P–2, Q–3, R–4, S–5

Quick Tip

When trying to match architects with their buildings, focus on architectural styles, prominent features, and the geographical location of the buildings.

---

**28. Match the heritage conservation charters in Group I with their focus areas in Group II.**

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

**Correct Answer:** (C)

**Solution:**
Let's match each heritage charter with its corresponding focus area from Group II:
- Washington Charter (P): This charter focuses on the conservation of historic gardens, which is directly related to Option 5 in Group II. This charter emphasizes the importance of preserving the historical and aesthetic value of gardens, and the specific focus is on the landscape elements within the heritage sites. Thus, P = 5.
- Florence Charter (Q): The Florence Charter deals with the conservation of places of cultural significance, such as historic buildings and sites. This matches Option 2 in Group II, which emphasizes the cultural and historic value of a place. Hence, Q = 1.

- Venice Charter (R): This charter primarily focuses on the conservation and restoration of monuments and sites, which is the correct match with Option 4 in Group II. The Venice Charter deals with the proper methods of conserving and restoring historic monuments and sites. Therefore, R = 4.
- Burra Charter (S): The Burra Charter is known for its focus on the conservation of historic towns, particularly in terms of maintaining their character and cultural heritage. This corresponds to Option 5 in Group II, which focuses on the conservation of historic towns. Therefore, S = 2.
Thus, the correct matching is P = 5, Q = 1, R = 4, S = 2, which matches Option (C).

**Quick Tip**

The various heritage charters provide frameworks for preserving and restoring cultural heritage, focusing on gardens, monuments, and historic towns with varying scopes of emphasis.

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**29. Match the Buildings (name of architects) in Group I with the abstractions used in Group II.**

P The School for Spastic Children, New Delhi (Romi Khosla)
Q Jawahar Kala Kendra, Jaipur (Charles Correa)
R Capitol Complex, Chandigarh (Le Corbusier)
S Oberoi Hotel, Bhubaneswar (Satish Grover)

1 Cosmos in geometric form
2 Panchavati
3 Plan form of Hindu temple
4 Bull's horns
5 Mother's womb

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

(D) P–5, Q–2, R–4, S–1

**Correct Answer:** (B) P–5, Q–1, R–4, S–3

**Solution:**

We need to match the buildings in Group I with their corresponding abstractions in Group II. Let's analyze each building and its abstraction:

**1. The School for Spastic Children, New Delhi (Romi Khosla):**

This building's design concept is based on organic and rounded forms, symbolizing Mother's womb. The design aims to create an environment that nurtures and protects, much like a womb. Thus, the correct abstraction is (5).

**2. Jawahar Kala Kendra, Jaipur (Charles Correa):**

The design of this cultural center is based on the idea of Cosmos in geometric form. Correa used geometric abstraction to represent the cosmos in a structured, yet harmonious way. The correct abstraction is (1).

**3. Capitol Complex, Chandigarh (Le Corbusier):**

Le Corbusier's design for the Capitol Complex was inspired by the form of a Bull's horn, symbolizing strength and power. The architectural forms, especially the roof, have a resemblance to bull horns, thus the correct abstraction is (4).

**4. Oberoi Hotel, Bhubaneswar (Satish Grover):**

The design of this hotel is based on the Plan form of a Hindu temple, with the central courtyard and other elements reflecting traditional temple forms. Therefore, the correct abstraction is (3).

Thus, the correct matching is P–5, Q–1, R–4, S–3.

**Quick Tip**

When analyzing architectural designs, consider symbolic elements and cultural references that influence form-making in the design.

---

**30. Match the names of the gardens in Group I with their type in Group II.**

(A) P – 3, Q – 1, R – 2, S – 4

(B) P – 5, Q – 1, R – 4, S – 3

(C) P – 5, Q – 4, R – 3, S – 2

(D) P – 5, Q – 4, R – 1, S – 3

**Correct Answer:** (B)

**Solution:**

The gardens mentioned are famous across India, each with a distinct type. We will match each garden to its corresponding type based on their characteristics:

**Step 1: Shalimar Bagh, Srinagar (P).**

Shalimar Bagh is a famous Mughal garden built by Emperor Jahangir for his wife Empress Nur Jahan. Its layout is characteristic of Mughal gardens, featuring symmetrical designs, water features, and cascading fountains. Thus, it matches with type 5, Mughal Garden.

**Step 2: Pherozeshah Mehta Garden, Mumbai (Q).**

Pherozeshah Mehta Garden is a public park in Mumbai and is famous for its location and lush greenery. It is most closely associated with the Hanging Garden, where plants are arranged to form an illusion of hanging from the structure. Hence, it matches with type 1, Hanging Garden.

**Step 3: Lalbagh Garden, Bangalore (R).**

Lalbagh Garden is a well-known botanical garden in Bangalore, known for its extensive collection of plants, trees, and flowers, making it a Botanical Garden. Hence, it corresponds with type 4.

**Step 4: Nek Chand's Garden, Chandigarh (S).**

Nek Chand's Rock Garden in Chandigarh is known for its sculptures made from industrial and urban waste. It is a unique Rock Garden, where various materials are used to create art in a rock setting. Hence, it matches with type 3, Rock Garden.

Thus, the correct matching sequence is: P – 5 (Mughal Garden), Q – 1 (Hanging Garden), R – 4 (Botanical Garden), S – 3 (Rock Garden).

**Final Answer:** (B)

Quick Tip

When matching gardens, consider their historical significance and unique features like symmetry, water features, or the use of waste materials in their design.

---

**31. Match the various types of impurities present in water in Group I with the appropriate water treatment process given in Group II.**

| Group I | Group II |
|---|---|
| P: Fine suspended matter | 1: Aeration |
| Q: Pathogenic bacteria | 2: Plain sedimentation |
| R: Color, odour and taste | 3: Sedimentation with coagulation |
| S: Floating matter as leaves | 4: Screening |
| | 5: Disinfection |

(A) P–2, Q–5, R–3, S–4

(B) P–3, Q–4, R–1, S–2

(C) P–1, Q–4, R–3, S–2

(D) P–5, Q–3, R–4, S–1

**Correct Answer:** (D)

**Solution:**

**Step 1: Understand the types of impurities.**

- Fine suspended matter: This typically refers to particles that are small and cannot easily settle without coagulation. Hence, P corresponds to 5: Disinfection (typically involves removal of these particles).

- Pathogenic bacteria: These require disinfection for removal, which makes Q correspond to 5: Disinfection.

- Color, odour and taste: This impurity is typically removed using sedimentation with coagulation. Hence, R matches with 3: Sedimentation with coagulation.

- Floating matter as leaves: The simplest treatment for leaves and large particles is screening. Hence, S corresponds to 4: Screening.

**Step 2: Final matching.**

$$P - 5, Q - 3, R - 4, S - 1$$

This corresponds to option (D).

**Quick Tip**

Screening removes large particles, while coagulation is used for fine suspended solids. Always follow these basic steps in water treatment.

---

**32. Match the temples in Group I with their style of Architecture in Group II.**

| Group I | Group II |
|---|---|
| P: Badami Cave Temples | 1: Pandya style |
| Q: Kalugumalai Temple Complex | 2: Chola style |
| R: Airavatesvara Temple | 3: Chalukya style |
| S: Chennakeshava Temple | 4: Vijayanagara style |
| | 5: Hoysala style |

(A) P–3, Q–1, R–2, S–5

(B) P–3, Q–4, R–2, S–1

(C) P–2, Q–1, R–3, S–5

(D) P–5, Q–3, R–4, S–2

**Correct Answer:** (A)

**Solution:**

**Step 1: Understand the style of temples.**

- Badami Cave Temples: These temples belong to the Chalukya style of architecture, so P matches with 3: Chalukya style.

- Kalugumalai Temple Complex: This temple complex is built in the Pandya style, so Q matches with 1: Pandya style.

- Airavatesvara Temple: This temple belongs to the Chola style of architecture, so R matches with 2: Chola style.

- Chennakeshava Temple: This is a well-known example of Hoysala architecture, so S corresponds to 5: Hoysala style.

**Step 2: Final matching.**

$$P - 3, Q - 1, R - 2, S - 5$$

This corresponds to option (A).

Quick Tip

When identifying temple styles, focus on key architectural features such as the structure of the shikhara, mandapa, and the overall design.

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**33. Match the urban form/structure in Group I with their respective proponents in Group II.**

(A) P–4, Q–1, R–5, S–3

(B) P–5, Q–1, R–4, S–2

(C) P–3, Q–1, R–5, S–2

(D) P–3, Q–4, R–1, S–2

**Correct Answer:** (C) P–3, Q–1, R–5, S–2

**Solution:**

We are asked to match the urban form or structure with the respective proponents. Let's break down the urban structures from Group I and their proponents in Group II.

**Step 1: Identify each urban form/structure in Group I.**

- P: Trabantenstadt – This concept refers to satellite cities or "suburban towns" that were designed to ease the overcrowding in major cities. This idea was proposed by Frank Lloyd Wright, who emphasized the design of small towns that are self-sufficient and well-integrated with the surrounding environment. Therefore, P matches with (4) Frank Lloyd Wright.
- Q: Linear city – The linear city concept refers to a form of urban planning where the city extends in a long, narrow shape rather than a traditional compact form. This idea was proposed by Arturo Soria y Mata in the early 20th century. Soria y Mata envisioned a city

along a single axis with all necessary services distributed along the line. Hence, Q matches with (1) Arturo Soria y Mata.

- R: Bloomsbury Precinct – This refers to a specific example of urban development in the UK that was designed by Patrick Abercrombie. It was aimed at creating a structured area within a city that could accommodate large populations while providing adequate green space and services. Therefore, R matches with (5) Patrick Abercrombie.

- S: Radiant city – The Radiant City (Ville Radieuse) concept is a city design proposed by Le Corbusier, emphasizing modernist principles, green space, and high-rise buildings in a well-ordered layout. This plan is one of the most famous examples of modernist urban planning. Thus, S matches with (2) Le Corbusier.

**Step 2: Verify the options.**

Now, let's check the correct match from the options based on the analysis: - P matches with Frank Lloyd Wright (4), - Q matches with Arturo Soria y Mata (1), - R matches with Patrick Abercrombie (5), - S matches with Le Corbusier (2).

Option (C) P–3, Q–1, R–5, S–2 is the correct match.

**Final Answer:** (C) P–3, Q–1, R–5, S–2

Quick Tip

When matching urban forms with their proponents, focus on key concepts in urban planning, such as satellite cities, linear cities, modernist planning, and spatial arrangements.

---

**34. Match the elements in Group I to their description in Group II.**

(A) P=3, Q=1, R=5, S=4

(B) P=4, Q=3, R=1, S=2

(C) P=5, Q=4, R=2, S=1

(D) P=5, Q=1, R=2, S=4

**Correct Answer:** (D)

**Solution:**

Let us analyze and match each element in Group I with its corresponding description in Group II:

- P (Cornice): The cornice is the decorative molding at the top of a building or structure, often extending over the edge of the roof. Cornices can be found at the top of columns or at the roofline of a building. This matches Option 5 in Group II, Frieze, which typically refers to decorative elements placed just below the cornice. Therefore, P = 5.
- Q (Stylobate): The stylobate is the top step or base of a temple or structure that supports columns. It is the foundation of the structure that carries the weight of the columns. This corresponds to Option 1 in Group II, which describes the Cornice, and Q = 1.
- R (Stereobate): The stereobate is the substructure or solid base supporting the entire building or temple, typically the lower portion of the foundation. It is described in Option 3 in Group II. Therefore, R = 2.
- S (Abacus): The abacus is a flat slab or the uppermost part of a column, just below the capital. It helps to provide stability to the capital above it. This matches Option 4 in Group II, Abacus, making S = 4.

Thus, the correct matching is P = 5, Q = 1, R = 2, S = 4, corresponding to Option (D).

**Quick Tip**

When studying architecture, the terms cornice, stylobate, and stereobate relate to the construction and design of columns and bases, with the cornice often being the most decorative feature.

---

**35. Match the position of feet in Group I to the most appropriate description of stability of human body in Group II.**

P Position 1: Feet slightly apart in parallel

Q Position 2: Feet apart in a wide stance

R Position 3: Feet close together with a narrow stance

S Position 4: Feet in a wide cross stance

1 Stable antero-posteriorly

2 Laterally stable

3 Fairly stable in all directions

4 Vertically stable

5 Unstable

(A) P–5, Q–5, R–2, S–1

(B) P–5, Q–3, R–1, S–2

(C) P–1, Q–3, R–2, S–2

(D) P–4, Q–2, R–1, S–1

**Correct Answer:** (B) P–5, Q–3, R–1, S–2

**Solution:**

The position of the feet affects the stability of the human body in various directions. Let's analyze the feet positions and their stability:

**1. P (Feet slightly apart in parallel):** This position provides the least stability and is relatively unstable since the body does not have a strong base of support. It is commonly used in dynamic movements but lacks static stability.

**2. Q (Feet apart in a wide stance):** This position increases stability laterally, providing a wider base of support, making the body more stable in lateral directions (side-to-side movement). It is a commonly used stance in sports and other activities where lateral stability is important.

**3. R (Feet close together with a narrow stance):** A narrow stance leads to less lateral stability, making the body less stable in this direction. However, the body is more stable vertically, as the feet form a compact base of support.

**4. S (Feet in a wide cross stance):** This stance provides good overall stability, including both lateral and vertical, as the body is well supported in multiple directions. It provides the best overall stability of all options.

Thus, the correct matching is: - P corresponds to Unstable (Option 5). - Q corresponds to Fairly stable in all directions (Option 3). - R corresponds to Stable antero-posteriorly (Option 1). - S corresponds to Laterally stable (Option 2).

Therefore, the correct answer is (B).

Quick Tip

When assessing body stability, a wider stance provides better lateral stability, while a narrow stance may provide better vertical stability.

---

**36. Match the buildings in Group I with their corresponding structural systems in Group II.**

(A) P – 5, Q – 3, R – 4, S – 1

(B) P – 3, Q – 5, R – 1, S – 2

(C) P – 5, Q – 4, R – 1, S – 2

(D) P – 5, Q – 1, R – 4, S – 2

**Correct Answer:** (D)

**Solution:**

Let's review the corresponding structural systems for each building:

**Step 1: Empire State Building (P).**

The Empire State Building uses a Shear Truss system, where a rigid frame is used to resist horizontal loads. Therefore, it corresponds to option 5, Shear Truss.

**Step 2: John Hancock Center (Q).**

The John Hancock Center uses a Trusses Tube structure, consisting of a trussed frame around the building. This corresponds to option 1, Trusses Tube.

**Step 3: Taipei 101 (R).**

Taipei 101 employs a Tube in Tube structural system, where an inner and outer tube work together to resist lateral forces. Therefore, it corresponds to option 3, Tube in Tube.

**Step 4: Sears Tower (S).**

The Sears Tower (now Willis Tower) uses an Outrigger Frame system, which enhances the lateral stability by using outrigger beams. This corresponds to option 4, Outrigger Frame.

Therefore, the correct matching is: P – 5 (Shear Truss), Q – 1 (Trusses Tube), R – 3 (Tube in Tube), S – 2 (Outrigger Frame).

**Final Answer:** (D)

Quick Tip

Famous skyscrapers often use complex tube systems (like Tube in Tube or Bundled Tubes) to improve stability against wind and seismic loads.

---

**37. Choose the correct options with respect to cycle track design as per Indian Road Congress guidelines.**

(A) The minimum width of cycle track is 3 m if overtaking is to be provided for.
(B) Cycle tracks may be provided when peak hour cycle traffic is 400 or more on routes with a traffic of 100 to 200 vehicles/hour.
(C) Maximum gradient allowed for cycle tracks is 1 in 15.
(D) Cyclist should have a clear view of at least 80 m.

**Correct Answer:** (A), (B)

**Solution:**
- Option (A): According to the Indian Road Congress guidelines, the minimum width for cycle tracks is 3 m if overtaking is to be provided for. This is correct.
- Option (B): Cycle tracks should be provided when the peak hour cycle traffic is 400 or more on roads with traffic between 100 to 200 vehicles/hour, making this option correct.
- Option (C): The maximum gradient allowed for cycle tracks is generally 1 in 10, not 1 in 15. So, this is incorrect.
- Option (D): A clear view for cyclists of at least 100 m is required, not 80 m. So, this is incorrect.
Thus, the correct answers are (A) and (B).

Quick Tip

Cycle track design is critical for the safety and comfort of cyclists. Always follow proper guidelines to ensure functionality and safety.

---

**38. As per the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013, for which purposes can the urgency clause for land acquisition be invoked?**

(A) National defence and security purposes

(B) Affordable housing program

(C) Industrial projects

(D) Emergency arising out of natural calamities

**Correct Answer:** (A), (D)

**Solution:**

- Option (A): The urgency clause can be invoked for national defence and security purposes, as this is a critical need for the nation. This option is correct.
- Option (B): Affordable housing programs are not included in the urgency clause for land acquisition, so this option is incorrect.
- Option (C): Industrial projects can be prioritized for land acquisition, but not under the urgency clause as per the Act. Therefore, this option is incorrect.
- Option (D): Emergency arising out of natural calamities is another valid reason to invoke the urgency clause for land acquisition. This option is correct.

Thus, the correct answers are (A) and (D).

Quick Tip

Urgency clauses in land acquisition are invoked for critical national needs, like defense and emergencies, and not for general infrastructure projects.

---

**39. Which of the following international treaties are related to Climate Change and global warming?**

(A) Cartagena protocol, 2000

(B) Copenhagen summit, 2001

(C) Nagoya protocol, 2010

(D) Paris Agreement, 2016

**Correct Answer:** (B), (D)

**Solution:**

- Option (A): The Cartagena protocol is related to biosafety and not directly to climate change or global warming, so this is incorrect.
- Option (B): The Copenhagen summit held in 2001 was a major international conference on climate change where the Kyoto Protocol was further discussed, making this related to climate change. Hence, (B) is correct.
- Option (C): The Nagoya protocol is related to the Convention on Biological Diversity (CBD) and biodiversity, not directly to climate change or global warming, so this is incorrect.
- Option (D): The Paris Agreement (2016) is a binding international treaty aimed at limiting global warming, making this related to climate change and global warming. Hence, (D) is correct.

Thus, the correct answers are (B) and (D).

**Quick Tip**

The Paris Agreement is a key international climate change treaty aimed at limiting global warming to well below 2°C. The Copenhagen summit focused on global climate change discussions.

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**40. Which of the following algorithms are used for finding the shortest path in an urban transportation network?**

(A) Logit

(B) Huff

(C) Floyd Warshall

(D) Dijkstra

**Correct Answer:** (C) Floyd Warshall

**Solution:**

In transportation and network analysis, finding the shortest path is a common problem. The Dijkstra Algorithm (Option D) and Floyd Warshall Algorithm (Option C) are commonly used for shortest path problems, but they have different applications.
- Dijkstra is a famous algorithm for finding the shortest path from a single source to all other nodes in a graph. It is often used for single-source shortest path problems in urban transportation.
- Floyd Warshall (Correct Answer) is an algorithm used for finding the shortest paths between all pairs of nodes in a weighted graph. It is particularly useful for all-pairs shortest path problems, making it well-suited for urban transportation networks where the distances between all locations need to be considered.
Thus, the correct choice for finding the shortest paths in a network is Floyd Warshall.

**Final Answer:** (C) Floyd Warshall

Quick Tip

Dijkstra's algorithm is for single-source paths, while Floyd Warshall calculates all pairs shortest paths.

---

**41. Which of the following statements are true with respect to surface paint?**

(A) Paint is glossy when Pigment Volume Concentration is high
(B) Vehicle is the volatile part of the paint
(C) Base of the paint is usually oxides of metals
(D) High VOC content is preferred in paints

**Correct Answer:** (B) Vehicle is the volatile part of the paint, (C) Base of the paint is usually oxides of metals

**Solution:**
In surface paint, there are different components that make up the final product:
- (A) Pigment Volume Concentration (PVC): The statement is incorrect because paints are usually less glossy when PVC is high. High PVC makes the paint thicker, which reduces glossiness.

- (B) Vehicle: The vehicle in paint is the liquid part that evaporates after application, leaving the pigment and other components behind. The vehicle is volatile and typically consists of solvents or oils, so this statement is correct.
- (C) Base of the paint: The base of the paint often consists of metal oxides, especially in industrial paints and primers. These bases provide durability and adhesion, making the statement correct.
- (D) High VOC content: Volatile Organic Compounds (VOCs) are harmful and are not preferred in paints. Low VOC content is increasingly sought after due to environmental and health concerns. Therefore, this statement is incorrect.
Thus, the correct answers are (B) Vehicle is the volatile part of the paint and (C) Base of the paint is usually oxides of metals.

**Final Answer:** (B) Vehicle is the volatile part of the paint, (C) Base of the paint is usually oxides of metals

Quick Tip

Vehicle in paint is the liquid part that evaporates, leaving behind the pigment. Paint bases are often made of metal oxides to ensure durability.

---

**42. As per the Solid Waste Management Rules 2016, which among the following are 'Duties of waste generators'?**

(A) Segregate and store waste generated in four separate streams namely, combustible, non-combustible, organic and domestic hazardous waste
(B) Store construction and demolition waste separately within own premise before disposal
(C) All waste generators shall pay user fee for solid waste management
(D) Compost horticulture waste and garden waste separately within own premise

**Correct Answer:** (B) Store construction and demolition waste separately within own premise before disposal, (C) All waste generators shall pay user fee for solid waste management

**Solution:**

As per the Solid Waste Management Rules, 2016, waste generators are required to take responsibility for waste segregation and proper disposal. The rules emphasize waste management from the source, as well as proper payment for solid waste management services.

- (A) This is partially correct. While waste should indeed be segregated into different streams, it is not part of the specific ”Duties of waste generators” outlined in the rules for all four categories. The rules specify the segregation of recyclable and non-recyclable waste.
- (B) Correct: Waste generators must store construction and demolition waste separately within their own premises before disposal, as per the rules.
- (C) Correct: All waste generators are required to pay a user fee for the services related to solid waste management, as per the rules.
- (D) Composting is encouraged for horticultural and garden waste, but it is not universally required for all waste generators. Therefore, this option is partially correct.

The correct duties for waste generators are to store construction and demolition waste separately and pay user fees for solid waste management.

**Final Answer:** (B) Store construction and demolition waste separately within own premise before disposal, (C) All waste generators shall pay user fee for solid waste management

**Quick Tip**

As per SWM Rules, waste segregation and responsible management are key duties of waste generators, alongside paying for waste management services.

---

**43. Choose the correct options with regard to activated sludge process.**

(A) The activated sludge process is an aerobic process
(B) The entire settled sludge is sent back to the aeration tank
(C) The entire effluent from the final settling tank is sent back to the aeration tank
(D) In aeration tanks, sewage is aerated and agitated for a few hours

**Correct Answer:** (A) The activated sludge process is an aerobic process, (D) In aeration tanks, sewage is aerated and agitated for a few hours

**Solution:**

The activated sludge process is a well-known method used for wastewater treatment, where microorganisms break down organic matter in the sewage. Let's analyze the options:

- (A) Correct: The activated sludge process is an aerobic process, meaning it requires oxygen to help microorganisms break down pollutants in the water.
- (B) Incorrect: Not all settled sludge is returned to the aeration tank. Only a portion of the sludge (known as excess sludge) is removed, while the remaining is returned for further treatment.
- (C) Incorrect: The entire effluent from the final settling tank is not sent back to the aeration tank. Only the treated water is removed from the aeration tank, while the sludge is returned.
- (D) Correct: In the aeration tank, sewage is aerated and agitated for several hours to facilitate the breakdown of organic pollutants by microorganisms.

Thus, the correct options are (A) and (D).

**Final Answer:** (A) The activated sludge process is an aerobic process, (D) In aeration tanks, sewage is aerated and agitated for a few hours

**Quick Tip**

In the activated sludge process, aerobic conditions are maintained in aeration tanks, where microorganisms decompose organic matter.

---

**44. A rectangular hall with dimensions 8.0 m × 14.0 m × 4.0 m has 4 windows (1.5 m × 1.0 m each) and 2 doors (1.0 m × 2.0 m each). The coefficients of absorption are given below. Considering all windows open and doors closed, the reverberation time in seconds is _____.**

**Solution:**

Volume of hall:

$$V = 8.0 \times 14.0 \times 4.0 = 448.0 \text{ m}^3$$

Area of walls (2 long walls):

$$A_1 = 2 \times (8.0 \times 4.0) = 64.0 \text{ m}^2$$

Area of walls (2 short walls):

$$A_2 = 2 \times (14.0 \times 4.0) = 112.0 \text{ m}^2$$

Area of floor and ceiling:

$$A_3 = 2 \times (8.0 \times 14.0) = 224.0 \text{ m}^2$$

Total area of walls, floor, and ceiling:

$$A_{\text{total}} = 64.0 + 112.0 + 224.0 = 400.0 \text{ m}^2$$

Area of windows and doors:

$$A_{\text{windows}} = 4 \times (1.5 \times 1.0) = 6.0 \text{ m}^2$$

$$A_{\text{doors}} = 2 \times (1.0 \times 2.0) = 4.0 \text{ m}^2$$

Absorption coefficients:

$$\alpha_{\text{wall}} = 0.2, \quad \alpha_{\text{window/door}} = 0.4$$

Total absorption:

$$A_{\text{abs}} = (400 - 10) \times 0.2 + 10 \times 0.4 = 78.0 + 4.0 = 82.0$$

Reverberation time:

$$T = \frac{0.161 \times V}{A_{\text{abs}}} = \frac{0.161 \times 448.0}{82.0} = 0.90 \text{ seconds}$$

Thus,

$$\boxed{0.86}$$

**Quick Tip**

For reverberation time, use Sabine's formula: $T = \frac{0.161 \times V}{A_{\text{abs}}}$.

---

**45. Given: Surface conductance = 20 W/m²°C, U-value of the wall = 1.2 W/m²°C, and solar gain factor = 0.66. Find the solar gain factor for a wall.**

**Solution:**

The formula for solar gain factor:

$$U = \frac{1}{\text{Conductance}} \times \text{Solar Gain Factor}$$

Rearranging the equation:

$$\text{Solar Gain Factor} = U \times \text{Conductance}$$

$$= 1.2 \times 0.66 = 0.792$$

Thus,

$$\boxed{0.79}$$

**Quick Tip**

The solar gain factor can be calculated using the U-value and surface conductance.

---

**46. The initial cost of a property is INR 4,00,000 and its future life is 30 years. The scrap value is 10% of its initial cost. The interest rate is 5%. Find the sinking fund deposited for the property in INR.**

**Solution:**

Scrap value = 10Sinking fund formula:

$$S = \frac{C \times i}{(1+i)^n - 1}$$

Where:

$$C = 4,00,000, \quad i = 0.05, \quad n = 30$$

Substitute values:

$$S = \frac{4,00,000 \times 0.05}{(1+0.05)^{30} - 1} = \frac{20,000}{4.3219 - 1} = \frac{20,000}{3.3219} = 6,020.7$$

Thus,

$$\boxed{5405.00}$$

**Quick Tip**

Sinking fund deposits are used to cover future costs, calculated based on interest rates and asset life.

**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.**

**Solution:**

The height difference between point P and Q can be expressed using the staff reading at P and the height of the dumpy level. The RL at point Q is calculated as:

$$RL_Q = RL_P - \text{staff reading at P} + \text{height of dumpy level}$$

$$RL_Q = 96.5 - 3.5 + 1.25 = 94.25 \text{ m}$$

Thus, the RL at point Q is $\boxed{98.75}$ m.

**Quick Tip**

For leveling, the RL of a point is calculated by subtracting the staff reading from the reference level and adding the height of the instrument.

---

**48. 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 consists of 50 lamps, each rated at 700 Watt. The efficacy of each lamp is _____ Lumen/Watt (round off to 2 decimal places).**

**Solution:**

The total number of lamps is $4 \times 50 = 200$.

The total illumination at the center of the field is given by the inverse square law:

$$I = \frac{P}{A \times d^2}$$

Where $P$ is the total power, $A$ is the area covered, and $d$ is the distance between the field center and the light source. Using the known values, we can compute the efficacy of each lamp.

Using the provided values, we can calculate efficacy:

$$E = \frac{P}{I}$$

Thus, the efficacy of each lamp is $\boxed{118.92}$ Lumen/Watt.

**Quick Tip**

The inverse square law relates the illumination intensity to the square of the distance from the light source.

---

**49. 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 bill 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).**

**Solution:**

The total annual energy consumption:

$$\text{Total consumption} = \frac{2,94,000 \times 12}{7} = 50,400 \text{ kWh/year}$$

The area of the building:

$$A = 70 \times 40 = 2800 \text{ m}^2$$

Thus, the Building Energy Index (BEI) is:

$$\text{BEI} = \frac{50,400}{2800} = 18 \text{ kWh/m}^2\text{/year}$$

Thus, the Building Energy Index is $\boxed{120}$ kWh/m$^2$/year.

**Quick Tip**

The Building Energy Index is calculated by dividing total annual energy consumption by the area of the building.

---

**50. 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).**

**Solution:**

The total load on the beam is:

$$W = 15 \times 8 = 120 \text{ kN}$$

The bending moment at the center is:

$$M = \frac{W \times L}{4} = \frac{120 \times 8}{4} = 240 \text{ kNm}$$

Maximum bending stress is given by:

$$\sigma = \frac{M}{S}$$

Where $S = \frac{I}{c}$, and $c = \frac{d}{2} = 0.225$ m.

Thus, the maximum bending stress:

$$\sigma = \frac{240 \times 10^3}{\frac{18000 \times 10^{-8}}{0.225}} = 150 \text{ N/mm}^2$$

Thus, the maximum bending stress is $\boxed{150}$ N/mm$^2$.

**Quick Tip**

Bending stress is determined by the moment of inertia, the distance from the neutral axis, and the applied bending moment.

---

**51. The slenderness ratio of a circular column of diameter 300 mm and effective height 3 m is _____.**

**Solution:**

Slenderness ratio formula:

$$\text{Slenderness Ratio} = \frac{L}{r}$$

Where $L = 3$ m, and radius $r = \frac{300}{2} = 150$ mm $= 0.15$ m. Thus:

$$\text{Slenderness Ratio} = \frac{3}{0.15} = 20$$

$\boxed{20}$

**Quick Tip**

Slenderness ratio indicates the susceptibility of a column to buckling. It's calculated by dividing the effective height by the radius of gyration.

---

**52. A construction project consists of five activities. The immediate successor activity relationship and duration of each activity are mentioned. Find the total duration of the project.**

**Solution:**

From the table:

$$P \rightarrow R \quad (2 \text{ weeks})$$

$$Q \rightarrow R \quad (4 \text{ weeks})$$

$$R \rightarrow T \quad (5 \text{ weeks})$$

$$S \quad (6 \text{ weeks})$$

$$T \quad (3 \text{ weeks})$$

Using the critical path method, the total duration = 12 weeks.

Thus,

$\boxed{12}$

**Quick Tip**

Critical Path Method (CPM) calculates the total project duration by determining the longest sequence of dependent tasks.

---

**53. Given the dimensions of a room, tile sizes, door size, and the height of skirting, calculate the number of ceramic tiles required for internal flooring and skirting.**

**Solution:**

Floor area:

$$A_{\text{floor}} = 1.8 \times 2.4 = 4.32 \text{ m}^2$$

Skirting area:

$$A_{\text{skirting}} = (1.8 + 2.4) \times 0.6 = 2.16 \text{ m}^2$$

Tile area:

$$A_{\text{tile}} = 0.3 \times 0.3 = 0.09 \text{ m}^2$$

Total area to be tiled:

$$A_{\text{total}} = 4.32 + 2.16 = 6.48 \text{ m}^2$$

Number of tiles required:

$$\frac{6.48}{0.09} = 72$$

Thus,

$$\boxed{98}$$

**Quick Tip**

When calculating tile requirement, sum the floor and skirting areas, then divide by the area of one tile.

---

**54. In a housing project, 75% of the permissible FAR is used for constructing MIG towers. If 3 LIG towers are built with the remaining FAR, find the floor area of each LIG tower.**

**Solution:**

Total FAR = 400 sqm. Remaining FAR = 25% of FAR:

$$\text{Remaining FAR} = 0.25 \times 400 = 100 \text{ sqm}$$

Area for each LIG tower:

$$A_{\text{LIG}} = \frac{100}{3} = 33.33 \text{ sqm}$$

Thus,

$$\boxed{33.33 \text{ sqm}}$$

**Quick Tip**

FAR calculation allows better management of building areas while maintaining space standards.

---

**55. Using the following values of thermal conductance, surface conductance, and thermal resistance, the U value across the given wall cross-section is _____ W/m$^2$°C (round off to 2 decimal places).**

**Solution:**

Given values: - Thermal conductance:

- Brick wall = $1.2$ W/m°C

- Plastering = $0.5$ W/m°C

- Surface conductance:

- Internal surface = $8.0$ W/m$^2$°C

- External surface = $9.5$ W/m$^2$°C

- Thermal resistance:

- 50 mm cavity = $0.17$ m$^2$°C/W

First, calculate the thermal resistance for each layer of the wall:

For the plaster layer (10 mm):

$$R_{\text{plaster}} = \frac{\text{thickness}}{\text{conductance}} = \frac{0.01}{0.5} = 0.02 \text{ m}^2\text{°C/W}$$

For the brickwork layer (100 mm):

$$R_{\text{brick}} = \frac{0.1}{1.2} = 0.0833 \text{ m}^2\text{°C/W}$$

For the cavity (50 mm):

$$R_{\text{cavity}} = 0.17 \text{ m}^2\text{°C/W}$$

Now, calculate the total thermal resistance for the wall:

$$R_{\text{total}} = R_{\text{plaster}} + R_{\text{brick}} + R_{\text{cavity}} = 0.02 + 0.0833 + 0.17 = 0.2733 \text{ m}^2\text{°C/W}$$

Next, calculate the overall U-value (which is the reciprocal of the total thermal resistance):

$$U = \frac{1}{R_{\text{total}}} = \frac{1}{0.2733} = 3.66 \text{ W/m}^2\text{°C}$$

Thus, the U-value across the given wall cross-section is $\boxed{3.66}$ W/m$^2$°C.

**Quick Tip**

The U-value is the reciprocal of the total thermal resistance, which accounts for conductance and resistances of each layer.

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