MADE EASY

India's Best Institute for IES, GATE & PSUs

Detailed Solutions

ISRO

CIVIL ENGINEERING

Written Test of Scientist/Engineer Examination

Date of Test : 12-01-2020

Set-A

- MADE EASY has taken due care in making solutions. If you find any discrepency/ typo/technical error, kindly mail us at: info@madeeasy.in
- Students are requested to share their expected marks.

www.madeeasy.in

Corporate Office: 44-A/1, Kalu Sarai, New Delhi - 110016 | **Ph:** 011-45124612, 9958995830

Delhi | Hyderabad | Noida | Bhopal | Jaipur | Lucknow | Indore | Pune | Bhubaneswar | Kolkata | Patna

ISRO (Scientist/Engineer) Examination
Civil Engineering : Paper Analysis
Exam held on 12.01.2020

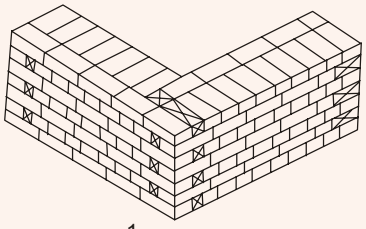
Sl.	Subjects	No. of Qs.	Level of Difficulty
1	Building Materials	9	Easy
2	Strength of Materials	10	Easy to moderate, repeated
3	Engineering Mechanics	2	Easy
4	Structural Analysis	1	Easy
5	Design of Steel Structures	5	Easy and repeated
6	RCC & Prestress Concrete	14	Moderate, repeated
7	Construction Practice, Planning & Management	2	Easy
8	Fluid & Hydraulic Machines + OCF	4	Moderate
9	Soil Mechanics	7	Moderate
10	Environmental Engineering	3	Easy
11	Transportation Engineering	3	Easy
12	Surveying	6	Easy
13	Engineering Hydrology	4	Easy
14	Irrigation Engineering	0	
15	Engineering Mathematics	10	Moderate

Q.1 The type of bond in a brick masonry containing alternate course of stretchers and headers is called

(a) Flemish bond
(b) English bond
(c) Stretcher bond
(d) Header bond

Ans. **(b)**

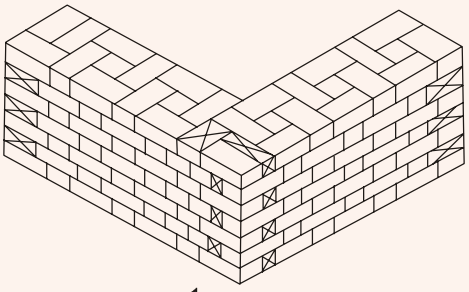
English Bond: It is the arrangement of bonding which consist of alternate courses of stretchers and headers."In order to break the alignment of vertical joints to fall in same straight line queen closer half is provided next to qunion header.



$1\frac{1}{2}$ Brick wall

Flemish Bond: In this arrangement of bonding brick work, each course consists of alternate headers and stretchers. The alternate headers of each course are centered over the stretchers in the course below. Every alternate course starts with a header at the corner. For breaking the vertical joints in the successive courses, closers are inserted in alternate courses next to the quoin header. In walls having thickness equal to odd number of half bricks, bats are essentially used to achieve the bond.

Flemish bond is further divided into two different types viz. Single Flemish bond and Double Flemish bond.



$1\frac{1}{2}$ Brick wall

End of Solution

Q.2 The unit of moment of inertia of an area is

(a) Kg/m
(b) Kg/sq.m
(c) m^4
(d) m^3

Ans. **(c)**

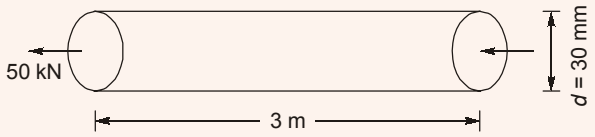
The unit of moment of inertia of an area is $(meter)^4$.

End of Solution

Q.3 A steel rod of 30 mm diameter and 3 m length is subjected to an axial pull of 50 kN. If $E = 200 \times 10^9$ pa, the elongation of the rod will be

(a) 2.225 mm (b) 1.062 mm
(c) 0.525 mm (d) 3.152 mm

Ans. **(b)**



$$\delta = \frac{PL}{AE} = \frac{(50\times10^3)(3\times10^3)}{\left(\frac{\pi}{4}\times30^2\right)(200\times10^9)} = 1.061\,\text{mm}$$

End of Solution

Q.4 The shape of the bending moment diagram over the length of a beam, carrying a uniformly increasing load is always

(a) Linear (b) Parabolic
(c) Cubic (d) Circular

Ans. **(c)**

The shape of the bending moment diagram over the length of a beam, carrying a uniformly increasing load is always cubic.

End of Solution

Q.5 Every material obeys Hooke's law within its

(a) Dimensional limit (b) Plastic point
(c) Limit of proportionality (d) Failure limit

Ans. **(c)**

Every material obeys Hooke's law within its limit of proportionality.

End of Solution

Q.6 An ideal flow of a liquid obeys

(a) Continuity equation (b) Newton's law of viscosity
(c) Newton's second law of motion (d) Dynamic of visocity law

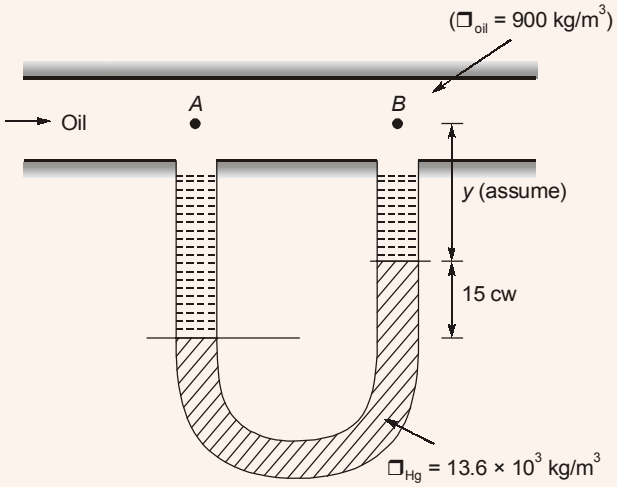
Ans. **(a)**

An ideal flow of a liquid obeys continuity equation.

End of Solution

Q.7 A pipe contains an oil of specific gravity 0.9. A differential manometer connected at the two points A and B shows a difference in mercury levels as 15 cm. The difference of pressure at the two points A and B will be
[Note : Consider the density of mercury as 13600 kg/m^3]
(a) 18688 N/m^2 (b) 15981 N/m^2
(c) 288 N/m^2 (d) 6528 N/m^2

Ans. **(a)**



$$P_A + (900)\, g\, (y + 0.15) = P_B + (900)\, gy + (13.6 \times 10^3)\, g\, (0.15)$$
$$P_A - P_B = (13.6 \times 10^3)\, g\, (0.15) - (900)\, g\, (0.15)$$
$$= 18688 \text{ N/m}^2$$

End of Solution

Q.8 Hydrograph is a representation of
(a) Surface run off (b) Ground water flow
(c) Rain fall (d) Discharge flow in the river

Ans. **(d)**
Hydrograph is a representation of discharge flow in the river.

End of Solution

Q.9 The quantity of water retained by the subsoil against gravity is known as
(a) Yield (b) Porosity
(c) Specific yield (d) Specific retention

Ans. **(d)**
Specific Retention, $SR = n - S_y$
where, n = Porosity
S_y = Specific yield

End of Solution

Q.10 A soil has a bulk density of 2.3 g/cm^3 and water content 15%, the dry density of soil sample is

(a) 2.0 g/cm^3 (b) 1.5 g/cm^3
(c) 1.0 g/cm^3 (d) 2.5 g/cm^3

Ans. **(a)**

$$\gamma_d = \frac{\gamma_t}{1+w} = \frac{2.3}{1+0.15} = 2 \text{ g/cc}$$

End of Solution

Q.11 The seepage exit gradient in a soil is the ratio of

(a) Total head to the length of the seepage
(b) Flow line to slope
(c) Head upstream to that at downstream
(d) Head loss to the length of the seepage

Ans. **(d)**

$$i = \frac{h_l}{l}, \; h_l = \text{head loss}, \; l = \text{length of seepage}$$

End of Solution

Q.12 A phreatic line is defined as the line within a dam below which there are

(a) Positive equipotential lines (b) Positive hydrostatic pressure
(c) Negative hydrostatic pressure (d) Negative equipotential lines

Ans. **(b)**

Hydrostatic pressure acts below the phreatic line whereas atmospheric pressure exists above the phreatic line. This line separates a saturated soil mass from an unsaturated soil mass. It is not an equipotential line, but a flow line.

End of Solution

Q.13 A saturated soil sample has water content of 40% and specific gravity of soil particle is 2.7. The void ratio of the soil is

(a) 0.4 (b) 0.52
(c) 1.08 (d) 2.0

Ans. **(c)**

$$eS = wG_s \qquad (S = 1)$$

$$e = \frac{0.4 \times 2.7}{1} = 1.08$$

End of Solution

Q.14 Separation of coarse aggregate from mortar transportation, is known as

(a) Bleeding (b) Creeping

(c) Segregation (d) Shrinkage

Ans. **(c)**

Segregation in concrete is commonly thought as separation of some size groups of aggregates from cement mortar in isolated locations with corresponding deficiencies of these materials in other locations. Segregation results in proportions of the laid concrete being in variation to those as designed.

Segregation could result from internal factors such as concrete that is not proportioned properly and not mixed adequately, or too workable a mix.

It also could result from external factors such as too much vibration, improper transportation, placement, or adverse weather conditions.

End of Solution

Q.15 The high strength of rapid hardening cement at early stage is due to its

(a) Addition of gypsum

(b) Burning at high temperature

(c) Higher content of tri-calcium silicate

(d) Reduced lime cement

Ans. **(c)**

Rapid hardening cement is a special type of cement that achieves high strength in less time. Normally the strength achieved by conventional cement in 7 days is same as the strength achieved in 3 days. This type of cement is also called as High-Early Strength Portland Cement.

It is manufactured by finely grinding cement clinkers and increasing the proportions of C_3S (Tri calcium silicate) and burning it at high temperature under more controlled conditions.

End of Solution

Q.16 If d and n are the effective depth and depth of the neutral axis respectively of a singly reinforced beam, the lever arm of the beam is

(a) d (b) n

(c) $d+\frac{n}{3}$ (d) $d-\frac{n}{3}$

Ans. **(d)**

If d and n are the effective depth and depth of the neutral axis respectively of a singly reinforced beam, the lever arm of the beam is $\left(d-\frac{n}{3}\right)$.

End of Solution

Q.17 Minimum spacing between horizontal parallel reinforcement bars of different diameters inter alia should not be less than
(a) One diameter of thinner bar
(b) One diameter of a thicker bar
(c) Sum of the diameters of the thinner and thicker bars
(d) Twice the diameter of the thinner bar

Ans. **(b)**
Minimum spacing between horizontal parallel reinforcement bars of different diameters inter alia should not be less than one diameter of a thicker bar.

End of Solution

Q.18 The characteristic load means the value of the load
(a) Below which not more than 5% of the results are expected to fall
(b) Which has a 95% probability of not being exceeded during the life of the structure
(c) Which has been factored with partial safety factor
(d) Which has a probability of being exceeded during the life of the structure

Ans. **(b)**
The characteristic load means the value of the load which has a 95% probability of not being exceeded during the life of the structure.

End of Solution

Q.19 Upon mixing water to the concrete ingredients, hydration takes place. The correct sequence of stages of hydration process are
(a) Hardening, setting, loss of workability
(b) Loss of workability, setting, hardening
(c) Setting, loss of workability, hardening
(d) Hardening, loss of workability, setting

Ans. **(c)**
Upon mixing water to the concrete ingredients hydration takes place in which initially it losses its plasticity (setting) then become stiff (loss of workability) and finally starts attaining strength (hardening).

End of Solution

Q.20 A column splice is used to increase
(a) Length of the column (b) Strength of the column
(c) Cross sectional area of the column (d) Connection with the slab

Ans. **(a)**
A column splice is used to increase length of the column.

End of Solution

Q.21 The distance travelled by a moving vehicle during perception and brake reaction time is known as

(a) Sight distance
(b) Stopping distance
(c) Lag distance
(d) Permissible distance

Ans. **(c)**

The distance travelled by a moving vehicle during perception and brake reaction time is known as lag distance.

End of Solution

Q.22 Maximum super elevation on hill roads not bound by snow should not exceed

(a) 5%
(b) 7%
(c) 8%
(d) 10%

Ans. **(d)**

Maximum super elevation on hill roads not bound by snow should not exceed 10% and maximum super elevation on hill roads bound by snow should not exceed 7%.

End of Solution

Q.23 The time by which an activity completion time can be delayed without affecting the early start of the succeeding activities is known as

(a) Duration
(b) Total float
(c) Free float
(d) Interfering float

Ans. **(c)**

Free float is the time by which an activity can be delayed without affecting succeeding activities.

End of Solution

Q.24 One Newton's force produces an acceleration of

(a) 1 cm/sec^2 while acting on a body of 1 gm mass
(b) 1 cm/sec^2 while acting on a body of 1 kg mass
(c) 1 m/sec^2 while acting on a body of 1 kg mass
(d) 1 m/sec^2 while acting on a body of 1 gm mass

Ans. **(c)**

$\because$ F = Mass × Acceleration

So, One Newton's force produces an acceleration of 1 m/sec^2 while acting on a body of 1 kg mass.

End of Solution

Q.25 Effective buckling length of a steel angle connected by double rivets is

(a) 0.7 L
(b) 0.85 L
(c) L
(d) 1.3 L

Ans. **(b)**

Effective buckling length of a steel angle connected by double rivets is 0.85L.

End of Solution

Q.26 Web crippling is a steel structure is on account of

(a) Column action of web
(b) Failure of web under concentrated load
(c) Excessive bending moment
(d) Secondary bending moment

Ans. **(b)**

Web crippling is a steel structure is on account of failure of web under concentrated load.

End of Solution

Q.27 The self-weight of a steel roof truss in N/m^2 may be computed by (span = l)

(a) $\left(\frac{l}{3}\right)+5$
(b) $\left[\left(\frac{l}{3}\right)+5\right]\times 10$
(c) $\left(\frac{l}{3}\right)-5$
(d) $\left[\left(\frac{l}{3}\right)-5\right]\times 10$

Ans. **(b)**

End of Solution

Q.28 A 40 cm diameter circular timber column is 4 m long. The slenderness ratio of the column is

(a) 4
(b) 10
(c) 20
(d) 40

Ans. **(d)**

$$I = Ak^2$$

$$k^2 = \frac{\frac{\pi}{64}D^4}{\frac{\pi}{4}D^2} = \frac{D^2}{16}$$

$$k = \frac{D}{4}$$

$$\text{S.R.} = \frac{L_e}{k} = \frac{(4\times 100)\text{cm}}{40/4} = 40$$

End of Solution

Q.29 For a given aggregate ratio, increasing water cement ratio

(a) Increases strength
(b) Decreases shrinkage
(c) Increases shrinkage
(d) Does not make any change in any parameter

Ans. **(c)**

With increase in water cement ratio, the amount of water in concrete increases, which affects the sample in following ways.

Strength: It decreases due to loss of excess water , leaving behind air voids, that reduces the availability of area to transfer the load.

Workability: It increases due to increases in lubricating action.

Compaction: For proper compaction less compactive effort is required at higher water cement ration.

Shrinkage: It increases as more water loss takes place during hydration.

End of Solution

Q.30 General ratio of cement : sand : aggregate in nominal mix M20 grade concrete is

(a) 1 : 2 : 4
(b) 1 : 1.5 : 3
(c) 1 : 3 : 6
(d) 1 : 1 : 2

Ans. **(b)**

Type of Concrete	Concrete Grade	Mix Ratio	Characteristic Compressive strength of Concrete @28Days in N/mm^2
Ordinary concrete	M5	1:5:10	5 N/mm^2
	M7.5	1:4:8	7.5 N/mm^2
	M10	1:3:6	10 N/mm^2
	M15	1:2:4	15 N/mm^2
	M20	1:1.5:3	20 N/mm^2
Standard Concrete	M25	1:1:2	25 N/mm^2
	M30	Design Mix	30 N/mm^2
	M35	Design Mix	35 N/mm^2
	M40	Design Mix	40 N/mm^2
	M45	Design Mix	45 N/mm^2
	M50	Design Mix	50 N/mm^2
High Strength Concrete	M55	Design Mix	55 N/mm^2
	M60	Design Mix	60 N/mm^2
	M65	Design Mix	65 N/mm^2
	M70	Design Mix	70 N/mm^2

End of Solution

Q.31 Which of the following is not considered in the design of the isolated footings?

(a) Bending moment
(b) Shear
(c) Punching stress
(d) Torsion

Ans. **(d)**

Isolated footings are designed for bending moment, one way shear and punching shear stress.

End of Solution

Q.32 In limit state method of design approach, spacing of main reinforcement primarily controls

(a) collapse (b) cracking
(c) deflection (d) durability

Ans. **(b)**

End of Solution

Q.33 The angle of dip at pole is

(a) 0° (b) 90°
(c) 45° (d) 30°

Ans. **(b)**

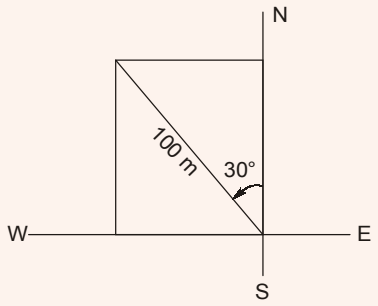
The angle of dip at pole is 90° and at equator is 0°.

End of Solution

Q.34 If the reduced bearing of line AB is N30W and length is 100 m, then the latitude and departure respectively of the line AB will be

(a) +86.6 m, +50 m (b) +50 m, +86.6 m
(c) +86.6 m, –50 m (d) –86.6 m, +50 m

Ans. **(c)**



$L = 100 \cos 30° = +86.6$ m

$D = 100 \sin 30° = -50$ m

End of Solution

Q.35 A circular curve has 300 m radius and 60° deflection angle. The length of curve and tangent length respectively are

(a) 200 m, 150 m (b) 314.16 m, 173.21 m
(c) 305.68 m, 158.73 m (d) 450 m, 220 m

Ans. **(b)**

$$\text{Tangent length} = R\tan\frac{\Delta}{2}$$
$$= 300 \tan 30°$$
$$= 173.21 \text{ m}$$
$$\text{Length of curve} = \frac{2\pi R}{360}\times 60$$
$$= \frac{2\pi R}{6} = \frac{2\times 3.14\times 300}{6}$$
$$= 314.16 \text{ m}$$

End of Solution

Q.36 The ranging operation in survey is a process of
(a) Reconnaissance
(b) Judging the distance
(c) Establishing intermediate points between terminals
(d) Determination of slope

Ans. **(c)**

End of Solution

Q.37 Zenith is the point on the celestial sphere
(a) Just below the observer's station
(b) Just above the observer's station
(c) Just on the left of the observer's station
(d) None of the above

Ans. **(b)**

End of Solution

Q.38 Fineness modulus of fine aggregate is 2.78 and of coarse aggregate is 7.82 and the desired fineness modulus of mixed aggregate is 6.14. What is the amount of fine aggregate to be mixed with one part of coarse aggregate?
(a) 55% (b) 50%
(c) 45% (d) 40%

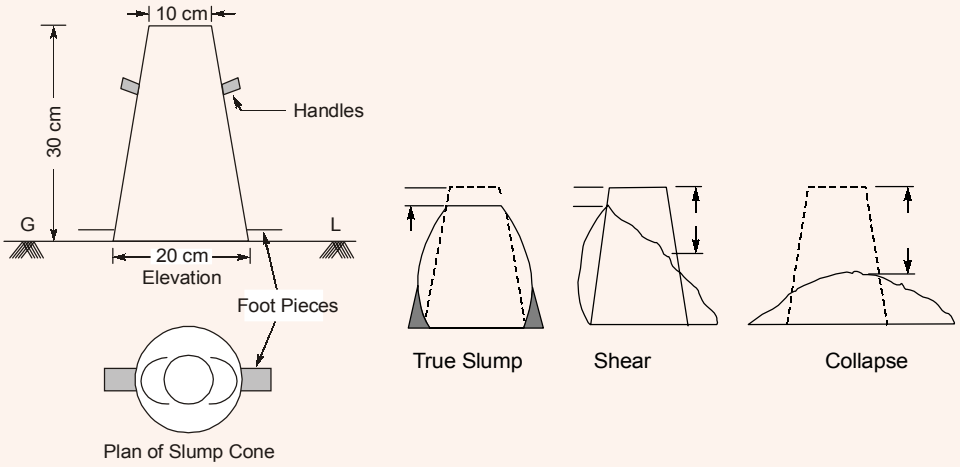
Ans. **(b)**
Let x fraction part of FA is to mixed with 1 part of CA to form the mix aggregate
$$2.78x + 7.82 = (1 + x)\ 6.14$$
$$x = 0.5\ (50\%)$$

End of Solution

Q.39 In what context is the slump test performed?
(a) Strength of concrete (b) Workability of concrete
(c) Water-cement ratio (d) Durability of concrete

Ans. **(b)**

The slump test is the most common method for assessing the flow properties of fresh concrete both in field and laboratory, due to the ease of its performance in which the slump provides a measure of workability. Using this test, the slump can be derived by measuring the drop from the top of the slumped fresh concrete.



Slump Test

End of Solution

Q.40 What is the ratio of flexural strength (f_{cr}) to the characteristic compressive strength of concrete (f_{ck}) of M25 grade concrete?

(a) 0.08 (b) 0.11

(c) 0.14 (d) 0.17

Ans. **(c)**

$$\text{Ratio} = \frac{f_{cr}}{f_{ck}} = \frac{0.7\sqrt{25}}{25} = 0.14$$

End of Solution

Q.41 Which of the following tests compares the dynamic modulus of elasticity of samples of concrete?

(a) Compression test (b) Ultrasonic pulse velocity test

(c) Split test (d) Tension test

Ans. **(b)**

An ultrasonic pulse velocity (UPV) test is an in-situ, nondestructive test to check the quality of concrete and natural rocks. In this test, the strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure or natural rock formation.

Ultrasonic Pulse Velocity can be used to:

- Evaluate the quality and homogeneity of concrete materials
- Predict the strength of concrete
- Evaluate dynamic modulus of elasticity of concrete
- Estimate the depth of cracks in concrete.
- Detect internal flaws, cracks, honeycombing, and poor patches.

End of Solution

Q.42 The bulk modulus of elasticity of a material is twice its modulus of rigidity. The Poisson's ratio of the material is

(a) $\frac{1}{7}$ (b) $\frac{2}{7}$

(c) $\frac{3}{7}$ (d) $\frac{4}{7}$

Ans. **(b)**

Given $K = 2G$

$$E = 3K(1 - 2V) = 2G(1 + V)$$

$$6G(1 - 2V) = 2G(1 + V)$$

$$V = \frac{2}{7}$$

End of Solution

Q.43 Two planks each of 50 mm × 50 mm section are glued together along the length to form a section 50 mm × 100 mm and used as a beam. If the shear force at a section is 1000 N, what is the maximum shear stress on the glue?

(a) 0.15 MPa (b) 0.3 MPa

(c) 0.6 MPa (d) 2.4 MPa

Ans. **(b)**

$$\tau_{max} = \frac{3}{2}\tau_{avg} = \frac{3}{2} \times \frac{1000}{50 \times 100} = 0.3 \text{ MPa}$$

End of Solution

Q.44 At a certain point in a structural member, there are perpendicular stresses 80 N/mm^2 and 20 N/mm^2, both tensile. While is the equivalent stress in simple tension, according to the maximum principal strain theory? [Poisson's ratio = 0.25]

(a) Zero (b) 20 N/mm^2

(c) 60 N/mm^2 (d) 75 N/mm^2

Ans. **(d)**

$$\epsilon_{p_1} = \epsilon_{eq}$$

$$\frac{\sigma_{p_1}}{E} - \frac{\mu\sigma_{p_2}}{E} = \frac{\sigma_{eq}}{E}$$

$$80 - (0.25)(20) = \sigma_{eq}$$

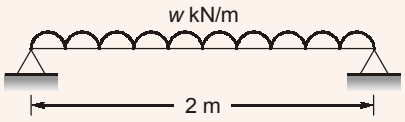
$$\sigma_{eq} = 75 \text{ MPa}$$

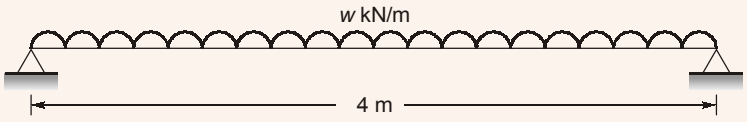
End of Solution

Q.45 Two simply supported beams are made up of the same material and are of the same cross-section. Both beam carry uniformly distributed loads of equal intensities. One beam is 2 m long and the other is 4 m long. The 2 m long beam shows a central deflection of 1 mm. What is the central deflection of 1 mm. What is the central deflection of the 4 m long beam?

(a) 16 mm (b) 2 mm
(c) 8 mm (d) 1 mm

Ans. **(a)**





$$\delta_1 = 1 \text{ mm}$$

$$= \frac{5}{384} \times \frac{wL^4}{EI}$$

$$\frac{\delta_2}{\delta_1} = \left(\frac{L_2}{L_1}\right)^4 = \frac{(4)^4}{(2)^4} = 16 \text{ mm}$$

End of Solution

Q.46 When the ratio of the long to short dimension of the slab is greater than *X*, the slab shall be designed as one-way slab, where *X* is

(a) 1.1 (b) 1.5
(c) 1.8 (d) 2.0

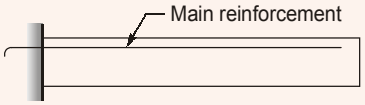
Ans. **(d)**

End of Solution

Q.47 A reinforced concrete cantilever porch has thickness *t*. The main reinforcement steel will be placed

(a) At mid-thickness
(b) At $\frac{t}{3}$ from the top
(c) Close to the bottom surface
(d) Close to the top surface

Ans. **(d)**



End of Solution

Q.48 A purely cohesive soil was tested by unconfined compression test. The mean unconfined compression strength was obtained as 50 kN/sq.m. The net ultimate bearing capacity of the soil adopting Terzaghi's concept will be
[adopt bearing capacity factor = 5.7, 1 kg appropriately equal to 10 N]
(a) 90 kN/sq.m
(b) 120 kN/sq.m
(c) 142.50 kN/sq.m
(d) 162.50 kN/sq.m

Ans. **(c)**

$$q_{nu} = 5.7\ C = 5.7 \times \frac{50}{2}$$

$$= 142.5\ kN/m^2$$

End of Solution

Q.49 Web buckling occurs in a beam due to excessive
(a) Direct tensile stress in the web
(b) Bending tensile stress in the web
(c) Torsional shear stress in the web
(d) Compressive stress in the web

Ans. **(d)**
Web buckling occurs in a beam due to excessive compressive stress in the web.

End of Solution

Q.50 In an isolated reinforced concrete footing of effective depth *d*, the stress in punching shear is checked
(a) at the centre of the column
(b) at the face of the column
(c) at a distance $\frac{d}{2}$ away from the face of the column
(d) at a distance $\frac{d}{2}$ from the centre of the column

Ans. **(c)**

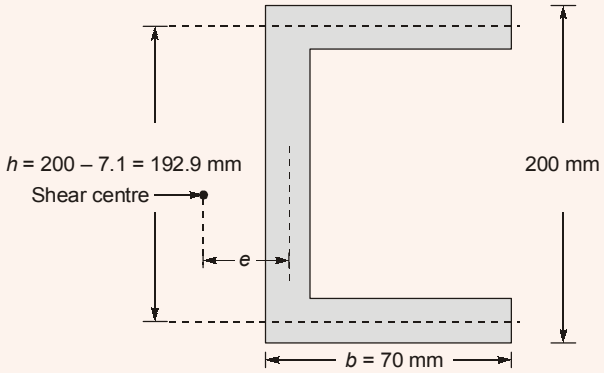
End of Solution

Q.51 An ISJC 200 channel section has the following details: width of flange 70 mm, depth of channel 200 mm, thickness of flange, $t_f = 7.1$ mm, moment of inertia, $I_{xx} = 1161.2\ mm^4$: The distance of shear centre from centre of the web will be

(a) 16.82 mm (b) 18.58 mm

(c) 22.87 mm (d) 27.87 mm

Ans. **(d)**



$$e = \frac{b^2h^2t}{4I}$$

$$= \frac{70^2 \times 192.9^2 \times 7.1}{4 \times 1161.2 \times 10^4} = 27.87 \text{ mm}$$

End of Solution

Q.52 Relative humidity is

(a) The relatives mass of water vapour per unit volume of space

(b) The mass of water vapour per unit mass of moist air

(c) The % ratio of the amount of moisture in a given space to the amount which that volume could contain if it were saturated

(d) The humidity at which air becomes saturated when cooled under constant pressure and with constant water vapour content

Ans. **(c)**

$$\text{Relative humidity} = \frac{e_a}{e_s} \times 100$$

End of Solution

Q.53 As per the Indian Standard specification for drinking water (IS : 10500 : 2012), what is the maximum acceptable limit of Fluoride (as F), in mg/*l*.

(a) 0.03 (b) 0.70

(c) 1.00 (d) 30

Ans. **(c)**

The acceptable limit is 1 mg/*l* and cause for rejection is 1.5 mg/*l*.

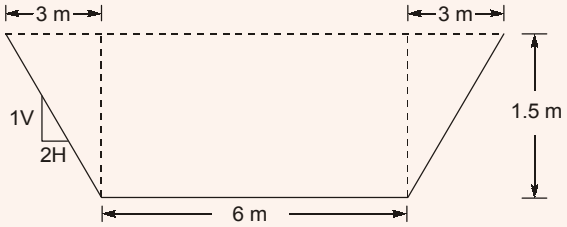
Preferable range for fluoride is taken as1-1.5 mg/*l*.

End of Solution

Q.54 A trapezoidal channel with base of 6 m and side slope of two horizontal to one vertical conveys water at 17 m^3/sec with a depth of 1.5 m. The flow situation in the channel is

(a) critical
(b) supercritical
(c) subcritical
(d) None of the above

Ans. **(c)**



$$F_r^2 = \frac{Q^2 T}{gA^3}$$

$$T = 12 \text{ m}$$

$$\Delta = \frac{1}{2}(6+12)\times 1.5 = 13.5 \text{ m}^2$$

$$F_r^2 = \frac{17^2 \times 12}{9.81 \times 13.5^3} = 0.14368$$

$$\therefore \quad F_r^2 = 0.379 < 1$$

$\Rightarrow$ Subcritical

End of Solution

Q.55 Consider the following statement associated with critical path

1. Critical path is the most important sequence of activities which has no float and which determine the project completion period.
2. Critical path is the largest path with shortest duration within which the project can be completed.
3. The difference between early start time and late finish time must be equal to the activity duration.
4. Cannot pass through dummy activity.

Which is among the above are correct statements?

(a) 1, 2 and 4
(b) 1, 2 and 3
(c) 1, 3 and 4
(d) 1, 2, 3 and 4

Ans. **(b)**

Critical path may pass through dummies. It depends on the network arrangement and duration of activities.

Alternatively,

$EST = T_E^i$ $\quad$ $LFT - EST = T_L^j - T_E^i$

$LFT = T_L^j$ $\quad$ $F_T = T_L^j - T_E^i - t^{ij}$

$\Rightarrow$ $\quad$ $0 = T_L^j - T_E^i - t^{ij}$

$\Rightarrow$ $\quad$ $T_L^j - T_E^i = t^{ij}$

Activity duration along critical path.
Statement 1, 2 and 3 is correct.
Critical path can consider dummies activities.

End of Solution

Q.56 Peak Gust wind speed as per IS 875 (Part 3) - 2015, for design loads is defined as
(a) Wind speed associated with maximum wavelength
(b) Wind speed associated with maximum frequency and velocity
(c) Wind speed associated with maximum amplitude
(d) Wind speed associated with maximum amplitude and wavelength

Ans. **(c)**
Peak Gust: A peak gust speed is the wind speed associated with the maximum amplitude.
Fetch length: It is the distance measured along the wind from a boundary at which a change in the type of terrain occurs.

End of Solution

Q.57 As per IS 875 (part-3) : 2015, while considering the wind load acting in direction normal to the individual structural element or cladding unit, the following is not considered
(a) Material density coefficient
(b) Internal and external pressure coefficients
(c) Surface area
(d) Design wind pressure

Ans. **(a)**

End of Solution

Q.58 As per Indian Standards, linear dynamic analysis shall be performed to obtain the design lateral force for all buildings other than
(a) Rectangular buildings lower than 15 m in seismic zone I.
(b) Regular buildings lower than 15 m in seismic zone II.
(c) Regular buildings lower than 10 m in seismic zone II.
(d) Rectangular buildings lower than 10 m in seismic zone I.

Ans. **(b)**

End of Solution

Q.59 A tube of aluminum of 40 mm external diameter and 20 mm internal diameter is snugly fitted on a solid steel rod of 20 mm diameter. The composite bar is subjected to an axial compressive force P. If the stress on steel bar is 70 N/mm^2, the stress in the aluminum tube and corresponding value of P will be
[E for steel 2×10^5 N/mm^2 and E for aluminum 7×10^4 N/mm^2]
(a) 24.5 N/mm^2, 45.08 kN
(b) 36.5 N/mm^2, 60.10 kN
(c) 54.5 N/mm^2, 73.10 kN
(d) 73.80 N/mm^2, 92.60 kN

Ans. **(a)**

$$P = P_1 + P_2 \qquad \text{...(i)}$$

$$\epsilon_{Al} = \epsilon_{Steel}$$

$$\frac{P_{Al}}{A_{Al}}\frac{L}{E_{Al}} = \frac{P_S}{A_S}\frac{L}{E_S}$$

$$\sigma_{Al} = \frac{E_{Al}}{E_S}\sigma_s = \frac{7\times10^4}{2\times10^5}\times70 = 24.5 \text{ MPa}$$

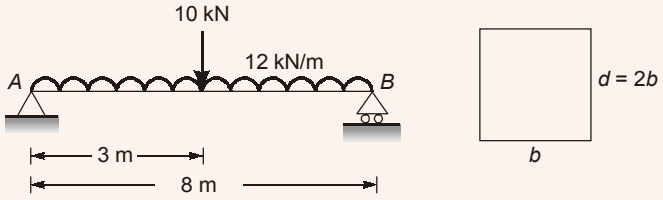
End of Solution

Q.60 A timber beam of rectangular section of length 8 m is simply supported. The beam carries a uniformly distributed load of 12 kN/m, over the entire length and a point load of 10 kN at 3 m from the left support. If the depth is two times the width and stress in the timber is not to exceed 10 N/mm^2, what is the suitable depth of the section?

(a) 412 mm (b) 512 mm

(c) 612 mm (d) 712 mm

Ans. **(b)**



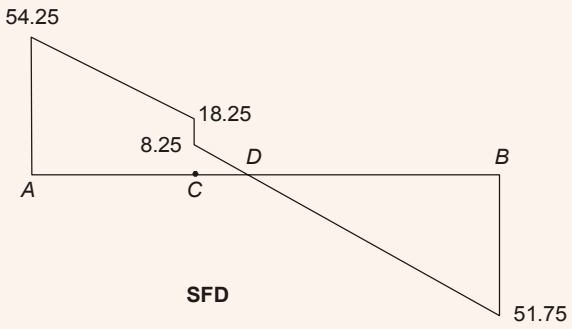
$$\Sigma M_B = 0$$

$$(V_A \times 8) + (-10\times5) + (-12\times8\times4) = 0$$

$$V_A = 54.25 \text{ kN}$$

$$54.25 + V_B = 10 + (12 \times 8)$$

$$V_B = 51.75 \text{ kN}$$



$$8.25 = 12x$$

$$\Rightarrow \quad x = 0.6875 \text{ m}$$

$$M_D - M_A = \left[\frac{1}{2}(54.25 + 18.5) \times 3\right] + \left[\frac{1}{2} \times 8.25 \times 6.875\right]$$

$$M_D = 111.58 \text{ kN-m}$$

$$6 = \frac{M \cdot y}{I}$$

$$10 = \frac{(111.58 \times 10^6)}{\left(\frac{d}{2}\right)\frac{d^2}{6}}$$

$$d = 511.59 \text{ mm} \simeq 512 \text{ mm}$$

End of Solution

Q.61 While aligning a hill road with a ruling gradient of 6%, a horizontal curve of radius 75 m is encountered, necessitating grade compensation. The compensated gradient at the curve will be

(a) 3.0% (b) 3.5%

(c) 4.5% (d) 5.0%

Ans. **(d)**

$$\text{Grade compensation} = \left.\begin{matrix}\frac{30+R}{R} \\ \frac{75}{R}\end{matrix}\right\} \text{Whichever is less}$$

$$\frac{30+R}{R} = \frac{30+75}{75} = 1.4\%$$

$$\frac{75}{75} = 1\%$$

$\therefore$ Compensated gradient = 6 – 1 = 5%

End of Solution

Q.62 If the average sewage from a city is 95×10^6 *l*/day and the average five-day BOD is 300 mg/*l*, the population equivalent of the city is

[Assume 5 day BOD percapita at 20°C = 0.075 kg/day]

(a) 2,10,000 (b) 3,80,000

(c) 5,10,000 (d) 6,25,000

Ans. **(b)**

$$\text{Population equivalent} = \frac{95\times10^6\ l/d\times300\ mg/l}{0.075\ kg/c/d\times10^6\ mg/kg}$$

$$= 3{,}80{,}000$$

End of Solution

Q.63 A pipe 1500 mm long and 200 mm in diameter is laid at a slope of 1 in 200 for the first half length and a slope of 1 in 100 for the second half length. The pressure at the upper and lower ends are respectively 1 kg/cm^2 (98.1 kN/m^2) and 0.5 kg/cm^2 (49.05 kN/m^2). If coefficient of friction, f = 0.04, the discharge in cum/sec will be

(a) 0.0324 (b) 0.0415

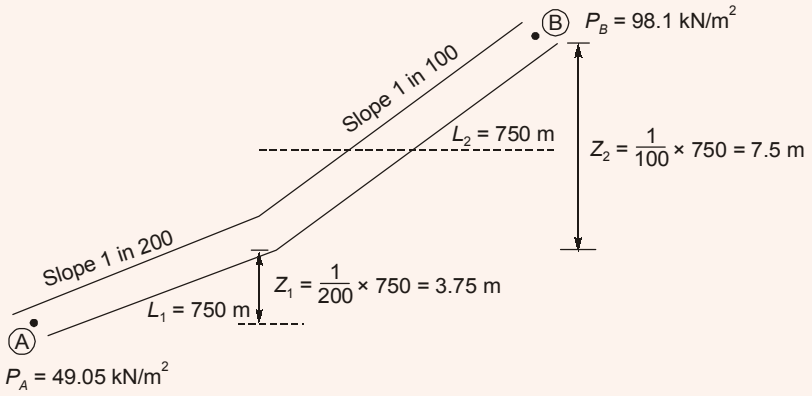
(c) 0.0489 (d) 0.0521

Ans. **(a)**

Given total length of pipe

$$L = L_1 + L_2$$

$$= 1500\ m \qquad (L_1 = L_2 = 750\ m)$$



$$Z_A = 0$$

$$Z_B = Z_1 + Z_2$$

$$= 3.75 + 7.5$$

$$= 11.25$$

$$\frac{P_B}{\rho g} + Z_B = \frac{98.1\times10^3}{10^3\times9.81} + 11.25 = 21.25\ m$$

$$\frac{P_A}{\rho g} + Z_A = \frac{49.05\times10^3}{10^3\times9.81} + 0$$

Apply energy eq. between (B) and (A)

$$\left[\frac{P_B}{\rho g} + Z_B\right] - \left[\frac{P_A}{\rho g} + Z_A\right] = \frac{8Q^2}{\pi^2 g}\times\frac{fL}{D^5}$$

$$21.25 - 5 = \frac{8Q^2}{\pi^2 g}\frac{(0.04)(1500)}{(0.2)^5}$$

$$Q = 0.0324 \text{ m}^3/\text{s}$$

Note: In this problem friction factor is misprinted as coefficient of friction otherwise no option will be correct.

End of Solution

Q.64 In an unconfined compression test, a sample clay 100 mm and 50 mm in diameter fails under a load of 150 N at 10% strain. What is the shearing resistance taking into account the effect of change in cross-section of the sample?

(a) 0.068 N/mm^2 (b) 0.088 N/mm^2

(c) 0.034 N/mm^2 (d) 0.044 N/mm^2

Ans. **(c)**

$$q_u = \frac{P}{A_o\left(\frac{1}{1-\varepsilon_a}\right)} = \frac{150}{\frac{\pi \times 50^2}{4}\left(\frac{1}{1-0.1}\right)} = 0.068 \text{ N/mm}^2$$

$$q_u = 2c\tan 45° + \frac{\phi}{2} \qquad (\phi = 0)$$

$$= 2c = 0.068$$

$$c = 0.034$$

Not $\tau = c + \sigma\tan\phi = 0.034$

End of Solution

Q.65 The density of a fully saturated specimen of clay having a water content of 40% is 1.88 gm/cc. On oven drying, the density drops to 1.74 gm/cc. The shrinkage limit of specimen will be [adopt ρ_w = 1.0 gm/cc]

(a) 13.12% (b) 16.18%

(c) 22.99% (d) 26.88%

Ans. **(c)**

End of Solution

Q.66 A camera equipped with a 152 mm focal length lens is used to take a vertical photograph from a flying height of 2780 m above mean sea level. If the terrain is flat and located at an elevation of 500 m, the scale of the photograph will be

(a) 1 : 15000 (b) 1 : 20000

(c) 1 : 22000 (d) 1 : 24500

Ans. **(a)**

$$S = \frac{f}{H-h} = \frac{152}{(2780-500)\times 10^3} = \frac{1}{15000}$$

So scale = 1 : 15000

End of Solution

Q.67 Rainfall intensities in mm/hr at half an hour interval during a 4-hour storm were: 5, 9, 20, 13, 6, 8, 16 and 3 mm/hr. If the corresponding observed runoff is 27.45 million m^3 from a basin having an area of 1830 Km^2? The ϕ-index for storm is

(a) 6.25 mm/hr (b) 6.7 mm/hr
(c) 7.2 mm/hr (d) 7 mm/hr

Ans. **(c)**

$$P = 40 \text{ mm}$$

$$Q = \frac{27.45 \times 10^6 \times 10^3}{1830 \times 10^6} = 15 \text{ mm}$$

$$\text{W-index} = \frac{P-Q}{t} = \frac{40-15}{4} = 6.25 \text{ mm/hr}$$

$$\Rightarrow \quad \phi\text{-index} = \frac{40-15-(5\times0.5)-(6\times0.5)-(3\times0.5)}{4-1.5}$$

$$= 7.2 \text{ mm/hr}$$

End of Solution

Q.68 An activated sludge tank is 30 m long 9 m wide and has liquid depth of 4 m. The influent sewage flow rate 3.5 MLD. The primary effluent has BOD of 130 mg/*l* and suspended load of 15 mg/*l*. The MLSS concentration in the aeration tank is 1800 mg/*l*. The corresponding F/M ratio is

(a) 0.19 (b) 0.23
(c) 0.32 (d) 0.46

Ans. **(b)**

$$\frac{F}{M} = \frac{Q_0 S_0}{VX} = \frac{3.5 \times 10^6 \, l/d \times 130 \text{ mg/}l}{(30 \times 9 \times 4) \text{ m}^3 \times 10^3 \, l/\text{m}^3 \times 1800 \text{ mg/}l}$$

$$= 0.234 \text{ d}^{-1}$$

End of Solution

Q.69 As per BIS 456-2000, deformed bars may be used without end anchorage provided

(a) Minimum spacing between the adjacent rod is ensured
(b) Sufficient cover is provided to the reinforcement bars
(c) Development length required is satisfied
(d) None of the above

Ans. **(c)**

End of Solution

Q.70 A propped cantilever beam of length L is subjected to a moment M at the propped end. The support moment at the fixed end will be

(a) M (b) $\frac{M}{2}$
(c) $\frac{M}{3}$ (d) $2M$

Ans. **(b)**

$$\text{COF} = \frac{1}{2} \quad \text{where far end is fixed}$$

$$\Rightarrow \quad \frac{M_A}{M} = \frac{1}{2}$$

$$\Rightarrow \quad M_A = \frac{M}{2}$$

End of Solution

Q.71 Consider a 3×3 real symmetric matrix A such that the two of its Eigen values are $a \neq 0$ and $b \neq 0$ with respective Eigen vectors $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}, \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}$. If $a \neq b$, then $x_1y_1 + x_2y_2 + x_3y_3$ equals

(a) a (b) b

(c) ab (d) 0

Ans. **(d)**

Eigen vectors corresponding to distinct eigen values of symmetric matrix are orthogonal.

$$x_1y_1 + x_2y_2 + x_3y_3 = x \cdot y = 0$$

End of Solution

Q.72 The area enclosed between the parabola $y = x^2$ and the straight line $y = x$ is

(a) $\frac{1}{8}$ (b) $\frac{1}{6}$

(c) $\frac{1}{3}$ (d) $\frac{1}{2}$

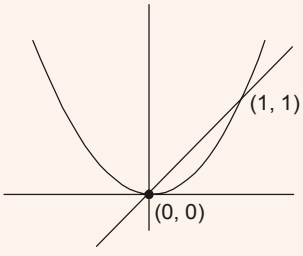
Ans. **(b)**

$$\text{Area, } A = \int_0^1 \int_{x^2}^{x} dy\, dx$$

$$= \int_0^1 [y]_{x^2}^{x} dx$$

$$= \int_0^1 \left[x - x^2\right] dx = \left[\frac{x^2}{2} - \frac{x^3}{3}\right]_0^1$$

$$= \frac{1}{2} - \frac{1}{3} = \frac{1}{6}$$



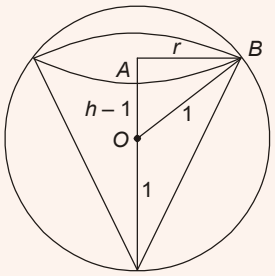
End of Solution

Q.73 The right circular cone of largest volume that can be enclosed by a sphere of 1 m radius has a height of

(a) $\frac{1}{3}$ m (b) $\frac{2}{3}$ m

(c) $\frac{11}{3}$ m (d) $\frac{4}{3}$ m

Ans. **(d)**



Volume of cylinder, $V = \frac{1}{3}\pi r^2 h$

From right angle triangle OAB

$$(h-1)^2 + r^2 = 1$$

$$r^2 = 2h - h^2$$

$$\therefore \quad V = \frac{1}{3}\pi(2h - h^2)h$$

$$= \frac{\pi}{3}(2h^2 - h^3) = f(h)$$

(1) $f'(h) = \frac{\pi}{3}(4h - 3h^2)$

(2) $f'(h) = 0 \Rightarrow h = 0, \frac{4}{3}$

(3) $f''(h) = \frac{\pi}{3}[4 - 6h]$

(4) $f''(0) = \frac{4\pi}{3} > 0$

$$f''\left(\frac{4}{3}\right) = -\frac{4\pi}{3} < 0 \text{ max at } h = \frac{4}{3}\text{m}$$

End of Solution

Q.74 Consider the function $f(x) = 2x^3 - 3x^2$ in the domain [–1, 2]. The global minimum of $f(x)$) is

(a) –5 (b) 0

(c) –1 (d) –7

Ans. **(a)**

$f(x) = 2x^3 - 3x^2$ in [–1, 2]

$f'(x) = 6x^2 - 6x$

$f'(x) = 0$

$\Rightarrow \quad 6x[x - 1] = 0$

$x = 0, 1$

$f(0) = 0$

$f(0) = -1$

$f(-1) = -5$

$f(2) = 4$

$\therefore$ Global minimum is $f(-1) = -5$

End of Solution

Q.75 The solution of $x\frac{dy}{dx}+y=x^4$ with condition $y(1)=\frac{6}{5}$ is

(a) $y=\frac{x^4}{5}+\frac{1}{x}$ (b) $y=\frac{4x^4}{5}+\frac{4}{5x}$

(c) $y=\frac{x^4}{5}+1$ (d) $y=\frac{x^4}{5}+4$

Ans. **(a)**

$$x\frac{dy}{dx}+y=x^4$$

$$\frac{dy}{dx}+\frac{y}{x}=x^3 \qquad \text{(Linear in } y\text{)}$$

$$\text{I.F.}=e^{\int\frac{1}{x}dx}=x$$

General solution,

$$y\,(\text{I.F.})=\int Q(I.F.)dx+C$$

$$y\,(x)=\int x^3\,x\,dx+C$$

$$xy=\frac{x^5}{5}+C$$

$$y(1)=\frac{6}{5}$$

$\Rightarrow$ $x=1,\ y=\frac{6}{5}$

$$\frac{6}{5}=\frac{1}{5}+C$$

$\Rightarrow$ $C=1$

$$xy=\frac{x^5}{5}+1$$

$\Rightarrow$ $$y=\frac{x^4}{5}+\frac{1}{x}$$

End of Solution

Q.76 The inverse Laplace transform of the function $F(S)=\frac{1}{S(S+1)}$ is

(a) $1-e^{-t}$ (b) $e^{-t}\sin t$

(c) e^{-t} (d) $\sin t$

Ans. **(a)**

$$L^{-1}\left\{\frac{1}{S(S+1)}\right\} = L^{-1}\left\{\frac{1}{S} - \frac{1}{(S+1)}\right\}$$
$$= 1 - e^{-t}$$

End of Solution

Q.77 Laplace transform of $e^{-2t}\cos(4t)$ is

(a) $\frac{s-2}{(s-2)^2+16}$ (b) $\frac{s+2}{(s-2)^2+16}$

(c) $\frac{s-2}{(s+2)^2+16}$ (d) $\frac{s+2}{(s+2)^2+16}$

Ans. **(d)**

$$= L\left\{e^{-2t}\cos 4t\right\}$$ By first shifting theorem

$$= \frac{s+2}{(s+2)^2+16}$$

End of Solution

Q.78 A box contains 2 washers, 3 nuts and 4 bolts. Items are drawn from the box at random, one at a time without replacement. The probability of drawing 2 washers frist followed by 3 nuts and subsequently the 4 bolts is

(a) $\frac{2}{315}$ (b) $\frac{1}{630}$

(c) $\frac{1}{1260}$ (d) $\frac{1}{2520}$

Ans. **(c)**

$$\text{Required prob.} = \frac{2}{9}\cdot\frac{1}{8}\cdot\frac{3}{7}\cdot\frac{2}{6}\cdot\frac{1}{5} = \frac{1}{1260}$$

End of Solution

Q.79 Consider an unbiased cubic dice with opposite faces coloured identically and each face coloured red, blue and green such that each colour appears only two times on the dice. If the dice is thrown thrice, the probability of obtaining red colour on the top face of the dice at least twice is

(a) $\frac{7}{27}$ (b) $\frac{10}{127}$

(c) $\frac{19}{27}$ (d) $\frac{1}{3}$

Ans. **(a)**

Prob of each colour comes on top = $\frac{2}{3} = \frac{1}{3}$

Using Binomial distribution

$$n = 3$$

$$P = \frac{1}{3} \text{ (Prob of red)}$$

$$q = \frac{2}{3}$$

$$P(\text{At least twice}) = P(x \geq 2)$$
$$= P(x = 2) + P(x = 3)$$
$$= {}^3C_2\left(\frac{1}{3}\right)^2\left(\frac{2}{3}\right) + {}^3C_3\left(\frac{1}{3}\right)^3$$
$$= \frac{6+1}{3^3} = \frac{7}{27}$$

End of Solution

Q.80 The argument of the complex number $\frac{1+i}{1-i}$, where $i = \sqrt{-1}$, is

(a) $-\pi$ (b) $-\frac{\pi}{2}$

(c) $\frac{\pi}{2}$ (d) $\frac{\pi}{3}$

Ans. **(c)**

$$\frac{1+i}{1-i} = \frac{(1+i)(1-i)}{(1-i)^2}$$
$$= \frac{1-i^2}{1+i^2-2i} = \frac{1+i}{-2i}$$
$$= -\frac{1}{i} = i$$

$$\text{Argument}\left(\frac{1+i}{1-i}\right) = \text{Arg}\,(i) = \frac{\pi}{2}$$

End of Solution

■■■■