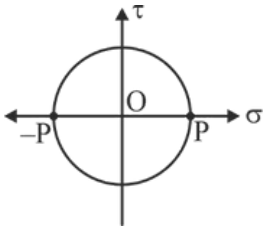
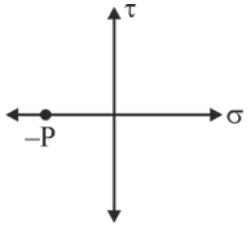
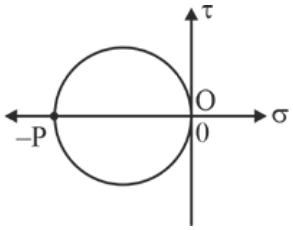
QUESTION-1 — MCQ

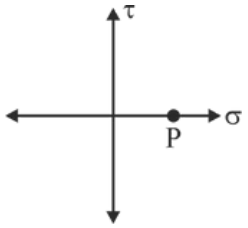
A metallic square plate is subjected to uniform hydrostatic pressure (P). Choose correct Mohr's circle representing state of stress at any point in the plate from the options given below.

For Mohr's circle (Normal stress is positive towards right, Shear stress is positive in upward direction)

(a) 

(b) 

(c) 

(d) 

SOLUTION: (b)

QUESTION-2 — NAT

A block of mass 1 kg connected to a spring of stiffness 10 Nm–1 is operating in a viscous medium such that damping ratio is equal to ratio of damped frequency to undamped natural frequency. The magnitude of damping ratio for system is_____ (Rounded off to two decimal places)

SOLUTION: (0.71)

Given:

m = 1 kg

s = 10 N/m

$\zeta = \frac{\omega_d}{\omega_n}$

$\zeta = ?$

$\square = \frac{\square}{\square n} = \sqrt{1 - \square 2}$

$\square = \sqrt{1 - \square 2}$

$\square 2 = 1 - \square 2$

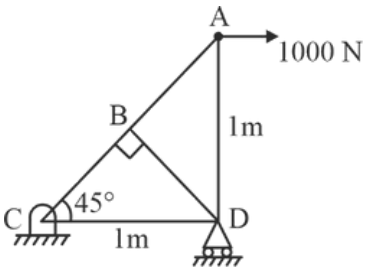
$2\square 2 = 1$

$\square = \frac{1}{\sqrt{2}}$

$\square =$ 0.71

QUESTION-3 — MCQ

For the given truss, among the options given, which member is zero force member ?



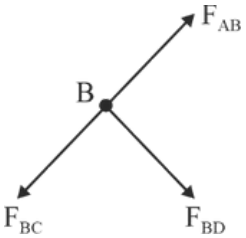
(a) BD (b) AD

(c) BC (d) BA

SOLUTION: (a)

Given:

FBD of Joint B;



From above FBD;

FAB = FBC

and

FBD = 0

QUESTION-4 — MCQ

The yield stress of metal in uniaxial tension is 200 MPa according to Von mises yield criterion. The yield stress (in MPa) of metal in pure shear is closest to

(a) 66.7 (b) 100.0

(c) 115.5 (d) 141.4

SOLUTION: (c)

Given:

Syt = 200 MPa

Ssy = ? (As per Von mises criteria)

$$Ssy = \frac{Syt}{\sqrt{3}} = \frac{200}{\sqrt{3}}$$

 Ssy = 115.47 MPa = 115.5 MPa

QUESTION-5 — MCQ

A shaft carries a helical spur gear, which one of the following bearing cannot be used to support it?

(a) Double row ball bearing (b) Angular contact bearing

(c) Tapered roller bearing (d) Straight roller bearing

SOLUTION: (d)

Helical gear imposes radial load and axial thrust on the bearings. Since straight roller bearings can bear radial loads only, it can't be used to support the provided shaft.

QUESTION-6 — MCQ

In context of balancing rotating and reciprocating masses, which one of following options is true?

(a) A single cylinder IC engine can be completely balanced using a single balancing mass.

(b) A single cylinder IC engine can be completely balanced using two balancing mass.

(c) An unbalanced rotor can be completely balanced using a single balancing mass.

(d) An unbalanced rotor can be completely balanced using two balancing mass attached in two distinct plane.

SOLUTION: (d)

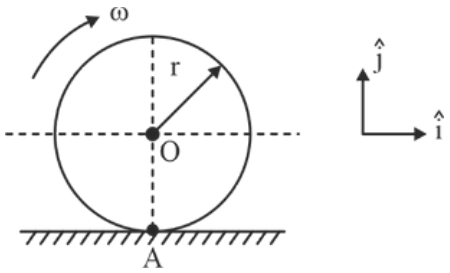
Given:

Unbalanced rotor can be balanced using two balancing masses in two different planes.

In this question option (d) is most correct answer as it covers both the cases of masses rotating in same plane as well as in different planes.

QUESTION-7 — MCQ

A rigid circular disc of radius r (in m) is rolling without slipping on a flat surface as shown in figure below. The angular velocity of disc is ω (in rad/s). The velocities (in m/s) at points O and A respectively are:



(a) $-r\omega\hat{i}$ and $0\hat{i}$

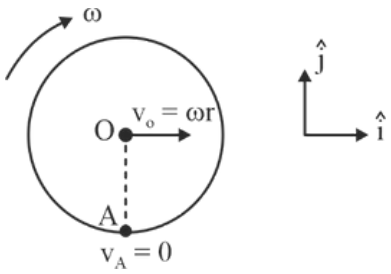
(b) $r\omega\hat{i}$ and $r\omega\hat{i}$

(c) $r\omega\hat{i}$ and $0\hat{i}$

(d) $-r\omega\hat{i}$ and $-r\omega\hat{i}$

SOLUTION: (c)

Given:



Since the disc is rolling without slipping hence velocity of point A;

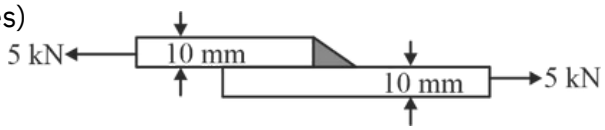
$v_A = 0\hat{i}$,

Velocity of point O;

$vO = r\omega\hat{i}$

QUESTION-8 — NAT

Two plates of thickness 10 mm each are to be joined by a transverse fillet weld on one side and resulting structure is loaded as shown in figure below. If ultimate tensile strength of weld material is 150 MPa and factor of safety to be used is 3. The minimum length of weld required to ensure that the weld does not fail is _____ mm. (Rounded off to two decimal places)



SOLUTION: (14.14)

Given:

h = 10 mm,

$t = \frac{h}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 7.071\text{mm}$

FOS = 3

L = ?

$\sigma_{t,\max} = \frac{P}{tL} = \frac{S_{ut}}{3}$

$\frac{5000}{7.071L} = \frac{150}{3}$

L = 14.142 mm

QUESTION-9 — MCQ

The endurance limit of a specific grade of steel is same as its yield strength. The ultimate strength of this grade of steel is twice of its yield strength. A component made of this steel is loaded in tension and unloaded periodically. It is required that the component does not fail for at least 106 loading cycle, as per Soderberg law. Considering a factor of safety of 2, the maximum applied tensile principal stress is

(a) One fourth of endurance limit
(b) Twice the endurance limit
(c) Half the endurance limit
(d) the endurance limit

SOLUTION: (c)

Given:

Se = Syt

Sut = 2Syt

FOS = 2

σ = ? (as per Soderberg's criteria)

$\sigma_a = \sigma_m = \frac{\sigma}{2}$

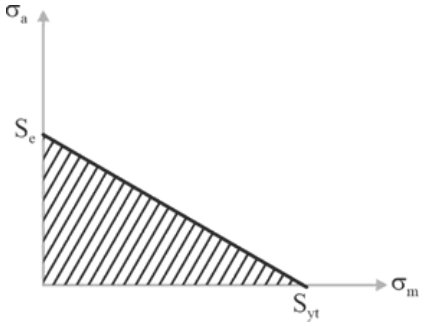
As per Soderberg's criteria,

$\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{yt}} = \frac{1}{FOS}$

$\frac{\sigma}{2S_e} + \frac{\sigma}{2S_e} = \frac{1}{2}$

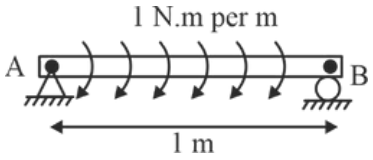
$\frac{\sigma}{S_e} = \frac{1}{2}$

$\sigma = \frac{S_e}{2} = 0.5S_e$

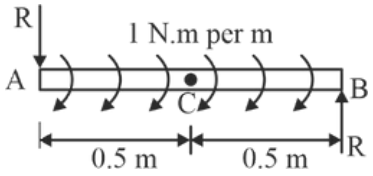


QUESTION-10 — NAT

A simple supported beam of length 1 m is subjected to uniformly distributed bending moment of 1 Nm per m throughout the length as shown in figure given below. The bending moment at mid-point of beam is_____ Nm (Rounded off to nearest integer)



SOLUTION: (0)



$\sum M_B = 0 \Rightarrow R \times 1 - 1 \times 1 = 0 \Rightarrow R = 1\ N$

Bending moment at C;

$M_C = 1 \times 0.5 - 1 \times 0.5$

$\Rightarrow M_C = 0$

QUESTION-11 — NAT

A pair of spur gear is required to maintain a velocity ratio of 1 : 2. The module of gear is 10 mm and addendum is 10 mm. If operating pressure angle is 15°, the minimum number of teeth required on pinion to ensure no interference/undercutting is _____ (Answer in integer)

SOLUTION: (25)

$V.R. = \frac{1}{2} \Rightarrow G = 2$

$m = 10$ mm

$\phi = 15°$

$t = ?$

$a_P = a_G = 10$ mm

Coefficient of addendum,

$AP = AG = \frac{10}{10} = 1$

Since addendum of pinion and gear are same, therefore to avoid interference/undercutting, the minimum number of teeth on gear,

$$T = \frac{2AG}{\sqrt{1 + \frac{1}{G}\left(\frac{1}{G} + 2\right)\sin^2\theta} - 1}$$

$$T = \frac{2\times 1}{\sqrt{1 + \frac{1}{2}\left(\frac{1}{2} + 2\right)\sin^2 15^\circ} - 1}$$

$T = 48.78 \rightarrow 49;\ t = \frac{T}{G} = \frac{49}{2} = 24.5$

Gear ratio;

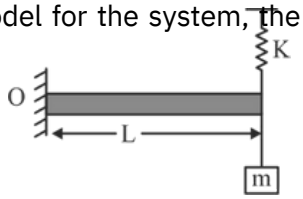
$G = \frac{T}{t} \times 2 = \frac{49}{t}$

$\therefore t = 24.5$ and corresponding $T = 50$

QUESTION-12 — MCQ

The system shown in figure below consists of cantilever beam (with flexural rigidity EI and negligible mass), a spring (with spring constant K and negligible mass) and a block of mass m.

Assuming lumped parameter model for the system, the fundamental frequency (ω_n) of the system is



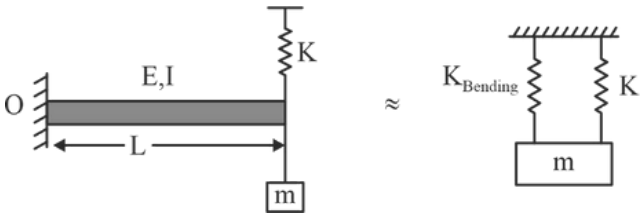
(a) $\frac{\frac{3EI}{L^3} + K}{2m}$

(b) $\frac{\frac{EI}{L^3} + K}{m}$

(c) $\frac{\frac{EI}{L^3} + K}{2m}$

(d) $\frac{\frac{3EI}{L^3} + K}{m}$

SOLUTION: (d)



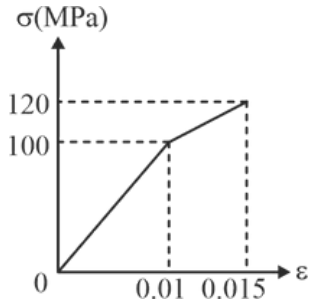
$\omega_n = \sqrt{\frac{K_{Bending} + K}{m}}$

Bending stiffness of the beam $K_{Bending} = 3EI/L3$

$$\omega_n = \sqrt{\frac{\frac{3EI}{L3} + K}{m}}$$

QUESTION-13 — NAT

An isotropic brittle material is tested in the universal testing machine. The stress strain diagram for the material shows a bi-linear elastic behavior as shown in figure given below. The strain energy density is _____ MJ/m3 (Rounded off to two decimal places).



SOLUTION: (1.05)

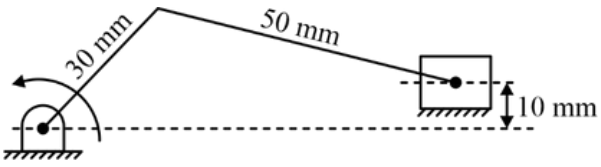
Given:

$$U_d = \frac{1}{2} \times 0.01 \times 100 + \frac{1}{2} \times 0.005 \times (100+120)$$

$$Ud = 1.05 \frac{MJ}{m3}$$

QUESTION-14 — NAT

An offset slider crank mechanism is shown in figure below. The length of stroke of slider is _____ mm (Rounded to nearest integer).



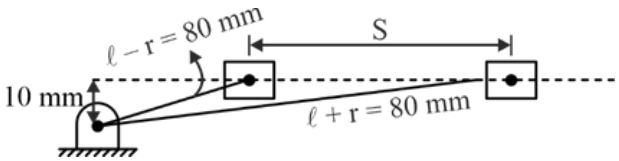
SOLUTION: (62.05)

Given:

r = 30 mm

ℓ = 50 mm

S = ?

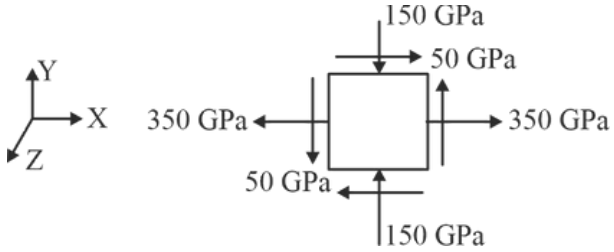


$S = \sqrt{802-102} - \sqrt{202-102}$

$\Delta S =$ 62.05mm

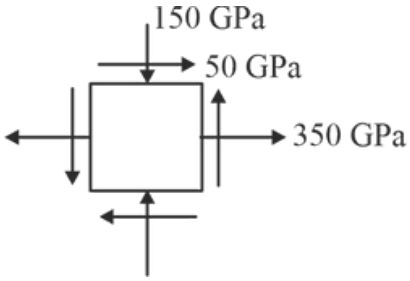
QUESTION-15 — NAT

The state of stress at a point is shown in the figure below. Under plane stress assumption, the normal strain along the thickness direction (ε_{zz}) is _____ (Rounded off to two decimal places) (E = 200 GPa and $\mu = 0.27$)



SOLUTION: (–0.27)

Given:



$$\varepsilon_{zz} = \frac{\sigma_z}{E} - \frac{\mu\sigma_x}{E} - \frac{\mu\sigma_y}{E}$$

$$\varepsilon_{zz} = 0 - \frac{0.27(350)}{200} - \frac{0.27(150)}{200}$$

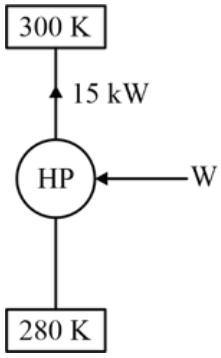
$$\varepsilon_{zz} = -0.27$$

SECTION-2	Fluid Mechanics and Thermal Sciences	Basic Thermodynamics Applied thermodynamics Heat Transfer Fluid Mechanics Fluid Machinery

QUESTION-16— NAT

Heat pump is working on reversed Carnot between temperature limit 300 K and 280 K. Heat lost through room is 15 kW then power input to the heat pump in kW.

SOLUTION: (1)



$$(COP)_{HP} = \frac{Th}{Th - TL} = \frac{300}{300 - 280} = 15$$

$$15 = \frac{15}{W_{in}}$$

Win = 1kW

QUESTION-17 — NAT

If the thermal efficiency of ideal air standard otto cycle is 0.5, specific heat ratio of air = 1.4, then compression ratio of cycle will be

SOLUTION: (5.65)

$$\eta = 1 - \frac{1}{r^{\gamma - 1}} = 0.5$$

$$\frac{1}{r^{\gamma - 1}} =$$

$$r^{\gamma - 1} = 2$$

$$r^{0.4} = 2$$

$$r = 5.65$$

QUESTION-18 — NAT

A hydrogen gas having polytropic index 1.3 and Cp = 14.56 kJ/kgK, Cv = 10.4 kJ/kgK, if the work done on the gas is 400 kJ then heat transfer

SOLUTION: (100)

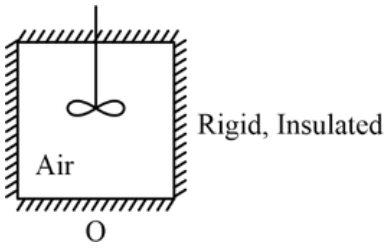
$$Q = \frac{(\gamma - n)}{(\gamma - 1)} W$$

$$Q = \frac{(1.4 - 1.3)}{(1.4 - 1)} 400$$

Q = 100 kJ

QUESTION-19 — NAT

Work is done on insulated rigid cylinder with the help of stirrer. Which of the following statements is correct?



(a) Enthalpy and entropy both increases

(b) Enthalpy and entropy both decreases

(c) Enthalpy and entropy both remains constant

(d) Enthalpy remains constant but entropy increases

SOLUTION: (a)

dQ = dW + dU

dQ = 0 (Insulated)

ΔT = + ve

H = f(T) only, therefore

enthalpy Δ

Change in specific entropy $= C \ln \left(\frac{T_f}{T_i}\right) + R \ln \left(\frac{V_f}{V_i}\right)$

Since Vi = Vf and Tf > Ti, therefore entropy

increases

QUESTION-20 — MSQ

Select correct option(s)

For fully developed pipe flow

(a) Compressibility becomes important when Mach number is less than 0.3

(b) For same maximum velocity, average velocity in turbulent flow is larger than the laminar flow regime.

(c) Friction factor is independent of surface roughness for laminar flow

(d) In laminar flow, friction factor decreases with decrease Reynolds number

SOLUTION: (b, c)

$$f = \frac{64}{Re}$$

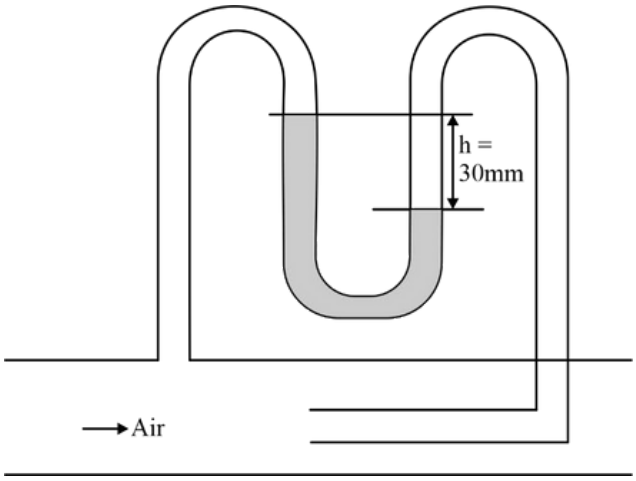
f = function (Re)

Re → f. f is independent of surface roughness in laminar flow

M 0.3 compressibility effects are not important

QUESTION-21 — NAT

A pitot tube is used to measure the velocity of air flowing in wind tunnel which has density of 1.23 kg/m3. The density of water is 1000 kg/m3, SG of manometric fluid is 13.6, Meniscus height is 30 mm. The velocity of air in the wind tunnel is



SOLUTION: (81.46)

$$V = \sqrt{2gh1}$$

$$h1 = \left(\frac{\rho_m - \rho_{air}}{\rho_{air}}\right) h$$

$h1 = \left(\frac{13600-1.23}{1.23}\right) 0.03$

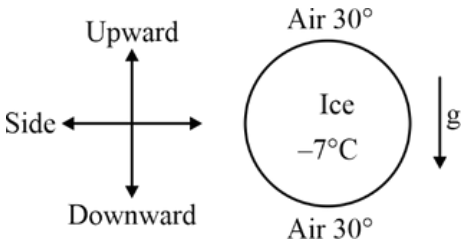
h1 = 331.67 m

$V = \sqrt{2 \times 9.81 \times 331.67}$

V = 81.46 m/s

QUESTION-22 — MCQ

Air at 30°C, a spherical ice cube at –7°C expose to air with gravity. What will be air direction?



(a) side (b) upward

(c) no motion (d) downward

SOLUTION: (d)

T_∞ = 30°C

T = –7°C

$T < T_\infty$

Air will go in the downward direction as it gets dense when it comes in contact with ice.

QUESTION-23 — NAT

For a Pelton wheel the diameter is 1 m if the absolute velocity of jet striking the blade is 125.66 m/s and the relative velocity is same at entry and exit. For maximum power generation the speed of the rotor in rpm is _____.

SOLUTION: (1200)

For maximum power transmission, $u = \frac{V_1}{2}$

$u = \frac{\pi DN}{60}$

V1 = absolute velocity of jet at inlet

$\frac{\pi DN}{60} = \frac{125.66}{2}$

πN=1200 rpm

QUESTION-24 — MCQ

Using Froude Number, $\frac{L_p}{L_m}$ =100. Velocity of model is given by 1 m/s. Find velocity of prototype in m/s?

(a) 100 (b) 10

(c) 1 (d) 0.1

SOLUTION: (b)

$(F)_m = (F)_p$

$$\frac{V_m}{\sqrt{L_m}} = \frac{Vp}{\sqrt{Lp}}$$

$$\Rightarrow Vp = V_m\sqrt{\frac{L_p}{L_m}}$$

$$\Rightarrow Vp = 1 \times \sqrt{100} = 10 \text{ m/s}$$

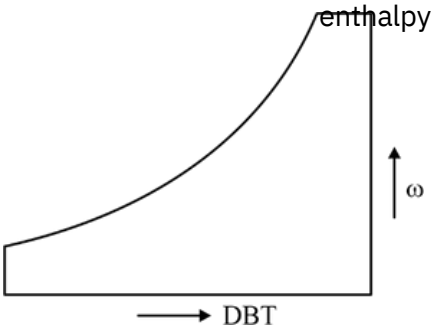
QUESTION-25 — MCQ

For a psychometric chart the x-axis represents the dry bulb temperature then y-axis represents

(a) Wet bulb temperature (b) relative humidity

(c) specific humidity (d) specific enthalpy

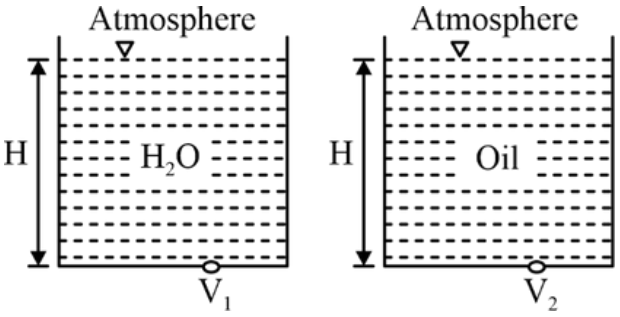
SOLUTION: (c)



In psychometric chart x-axis represents dry bulb temperature and y-axis represents specific humidity.

QUESTION-26 — MCQ

Two tanks have holes at the bottom. In one tank there is water and in other engine oil, height of liquid is the same in both. If both the tank are identical, then relationship between V1 and V2 is _____.



(a) V2 = V1 (b) V2 □ V1 (c) V2 □ V1

(d) relationship with V1 and V2

SOLUTION: (a)

$V = \sqrt{2gH}$

Exit velocity is independent of type of fluid when losses are neglected

□ V1 = V2

QUESTION-27 — NAT

The velocity vector for a flow is given $V = 3z\hat{i} + 0\hat{j} + Cxk$. For an irrotational flow the value of by c is _____.

SOLUTION: (3)

$\nabla = 3z\hat{i} + Cxk = u\hat{i} + v\hat{j} + wk\hat{}$

For irrotational flow

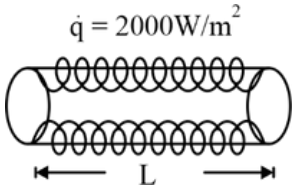
□ □ $\nabla = \bar{0}$

$$\begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 3z & 0 & Cx \end{vmatrix} = \bar{0}$$

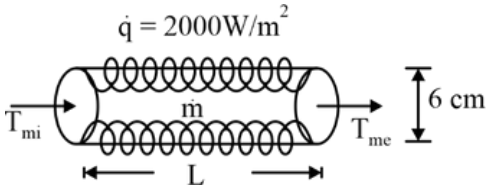
□ C = 3

QUESTION-28 — NAT

Water is flowing through a pipe. The inlet and outlet bulk mean temperature of water are 293 K and 353 K respectively. If mass flow rate of water is 0.01 kg/s and diameter of tube is 60 mm, then length of the tube if constant heat flux of 2000 W/m2 is subjected to wall of the pipe is _____ m.



SOLUTION: (6.65)



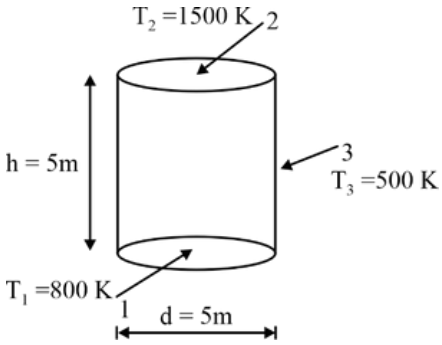
Energy balance

$q \cdot dL = \dot{m} c_p (T_{me} - T_{mi})$

$200 \times \pi \times 0.06 \times L = 0.01 \times 4180 \times (353 - 293)$

$L = 6.65$ m

QUESTION-29 — NAT



$F_{12} = 0.2$

$\sigma = 5.67 \times 10^{-8}$ W/mK^4

All are black surface. Find net heat transfer from bottom to curve surface in _____ kW.

SOLUTION: (310.14)

$F_{11} + F_{12} + F_{13}$

$= 1 \Rightarrow 0 + 0.2 + F_{13}$

$= 1 \Rightarrow F_{13} = 0.8$

$(\dot{Q}_{13})_{Net} = \dot{Q}_{13} - \dot{Q}_3$

1

$\dot{Q}_{13} = A_1 F_{13} \sigma T_1^4$

$= \pi R^2 \times 0.8 \times 5.67 \times 10^{-8} \times 800^4$

$\therefore \dot{Q}_{13} = 364.806 kW$

$A_1 F_{13} = A_3 F_{31}$

$F_{31} = \frac{A_1}{A_3} F_{13} = 0.2$

$\dot{Q}_{31} = A_3 F_{31} \sigma T_3^4$

$= \pi DL \times 0.2 \times 5.67 \times 10^{-8} \times 500^4$

$\dot{Q}_{31} = 55.665 kW$

$\dot{Q}_{Net} = \dot{Q}_{13} - \dot{Q}_{31} = 364.806 - 55.665$

$\therefore Q_{Net} = 310.14 kW$

QUESTION-30 — NAT

The condition of steam at inlet and outlet of the turbine is given below:

Super heated condition

h1 = 3344 kJ/kg

S1 = 6.5 kJ/kgK

At condenser pressure

Sf = 1.1 kJ/kgK

Sg = 7.6 kJ/kgK

hf = 341 kJ/kg

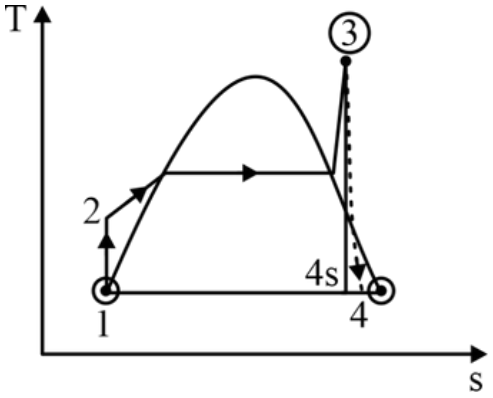
hg = 2645 kJ/kg

Mass flow rate = 102 kg/s

Isentropic efficiency = 0.9

Calculate the turbine power in MW

SOLUTION: (99.275)



$\eta_{is,t} = 0.9$

$\dot{m}=102kg/s$

W = ?

S3 = 6.5

S4s = 6.5 = 1.1 + x (7.6 – 1.1)

x = 0.8307

h4s = 341 + 0.8307 (2654 – 341)

h4s = 2262.56

$\eta_{isen} = \frac{w_{net}}{\Delta h_s}$ $w_{net} = 0.9(3342262.56)$

$\dot{W}_{net} = \dot{m} \times w_{net} = 102 \times 973.28$

$\boxed{P = 99.275MW}$

SECTION-3	Materials, Manufacturing, and Industrial Engineering	Manufacturing Engineering Industrial Engineering Material Science

QUESTION-31 — MCQ **(1 Mark)**

Welding process commonly used for fabricating tailor welded blanks of dissimilar thickness for automotive application is

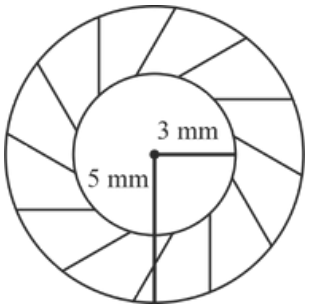
(a) gas welding
(b) arc welding
(c) friction welding
(d) laser welding

SOLUTION: (d)

Laser welding is a commonly used process for fabricating tailor-welded blanks (TWBs) of dissimilar
thickness for automotive applications. TWBs are blanks made from two or more sheets of metal with different thicknesses, welded together to form a single blank

QUESTION-32 — NAT **(1 Mark)**

In welding operation, the thermal power of 2500 W is incident normally on a metallic surface. As shown in the given figure (the figure is not in scale) the heated area is circular. Out of incident power 85% of power absorbed within a circle of Radius 5 mm and 65% of power absorbed within an inner concentric circle of Radius 3 mm. The power density of shaded area _____ W/mm2 (Round off two decimal places).



SOLUTION: (9.94)

Power density of shaded area $= \frac{2500 \times (85 - 65)\%}{\pi \times 10^{-2} \times \left(\frac{6}{2}\right)^2} = 9.947 \text{W/mm2}$

QUESTION-33 — MCQ **(1 Mark)**

Among the following the surface hardening process, steel is heated to the lowest temperature in

(a) nitriding
(b) cyaniding
(c) carburizing
(d) carbonitriding

SOLUTION: (a)

Nitriding is a surface hardening process in which steel is heated to a relatively low temperature, typically between 500°C to 600°C, in a nitrogen-rich atmosphere. This process diffuses nitrogen into the steel surface, creating a hard and wear-resistant layer.

In comparison, the other options require higher temperatures:

- Cyaniding: 760°C to 870°C
- Carburizing: 850°C to 950°C
- Carbonitriding: 800°C to 900°C

QUESTION-34 — MCQ **(1 Mark)**

In Computer-aided design (CAD), solid models can be constructed using.

(a) Non uniform rational B-spline (NURBS)

(b) Bezier curves

(c) Boundary representation (B-rep)

(d) B-Splines

SOLUTION: (a)

Non-uniform rational basis spline (NURBS) is a mathematical model using basis splines (B-splines) that is commonly used in computer graphics for representing curves and surfaces. It offers great flexibility and precision for handling both analytic (defined by common mathematical formulae) and modeled shapes. It is a type of curve modeling, as opposed to polygonal modeling or digital sculpting. NURBS curves are commonly used in computer-aided design (CAD), manufacturing (CAM), and engineering (CAE). They are part of numerous industry-wide standards, such as IGES, STEP, ACIS, and PHIGS. Tools for creating and editing NURBS surfaces are found in various 3D graphics, rendering and animation software packages.

QUESTION-35 — NAT **(2 Marks)**

Demand = 3000 units/yr

Ordering cost = ₹ 150

Holding cost = 40% of purchase price/unit on annual basis.

The minimum total annual cost is ₹ _____ (Round off 1 decimal places).

Lot size	Unit price (₹)
1 – 499	9
500 – 999	8.5
1000 or more	8

SOLUTION: (26050)

Take unit price = ₹8

$$Q = \sqrt{\frac{2DCo}{Ch}} = \sqrt{\frac{2 \times 3000 \times 150}{0.40 \times 8}} = 530.33 \text{ Not Feasible.}$$

Take unit price = ₹8.5

$$Q = \sqrt{\frac{2DCo}{Ch}} = \sqrt{\frac{2 \times 3000 \times 150}{0.40 \times 8.5}} = 514.50 \text{ units feasible}$$

$$TIC(Q = 514.50) = DC + \frac{D}{Q}Co + \frac{Q}{2}Ch$$

$$= 3000 \times 8.5 + \frac{3000}{514.50} \times 150 + \frac{514.50}{2} \times 0.4 \times 8.5 = \text{Rs. } 27249.28$$

At Q = 1000

$$TIC = 3000 \times 8 + \frac{3000}{1000} \times 150 + \frac{1000}{2} \times 0.4 \times 8 = \text{Rs. } 26050 \text{ (Ans.)}$$

QUESTION-36 — MCQ **(2 Marks)**

The thickness of the sheet is 30 mm and feed it into two powered rolls.

We get 27 mm thickness in single pass (no change in width).

The diameter of the roller is 500 mm. The process feasibility and maximum draft (mm) can be represented respectively, the coefficient friction is 0.12

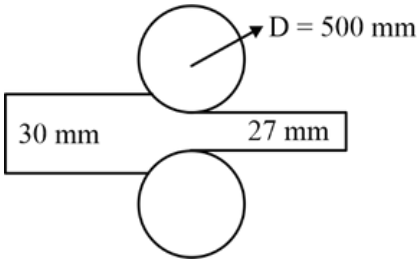
(a) Feasible, and 3.6

(b) Feasible and 3

(c) Not feasible and 2.6

(d) Not feasible and 6

SOLUTION: (a)



$(\Delta h)_{max} = \mu^2 R = 0.12^2 \times 200 = 3.6$ mm

So, the process is feasible.

QUESTION-37 — MCQ **(1 Mark)**

Glass and ceramic are machined by

(a) (c) Transferred arc plasma machining (b) ECM

(c) USM (d) EDM

SOLUTION: (c)

Ultrasonic Machining (USM) is a non-traditional machining process that uses high-frequency vibrations to remove material from hard, brittle, and non-conductive materials like glass and ceramics. The process involves:

1. A tool vibrating at high frequency (typically 20 kHz)

2. An abrasive slurry that helps remove material

3. The tool is pressed against the workpiece, and the vibrations create a cavitation effect that

removes material

QUESTION-38 — NAT **(2 Marks)**

The cylindrical workpiece has

Diameter (D) = 60 mm, Length (L) = 400 mm,

Cutting speed (V) = 25 m/min

Feed (F) = 0.2 mm/rev, Tailor constant (C) = 75, Exponent (n) = 0.25,

Tool changing time (TC) = 3 min

Laboure and overhead cost = ₹ 5/min

Tool changing cost/price = ₹ _____ (Round off two decimal places).

SOLUTION: (3)

$$N = \frac{1000V}{\pi D} = \frac{1000\times 25}{(\pi)(60)} = 132.63 \text{ rpm}$$

$$T_m = \frac{L}{fN} = \frac{400}{0.2\times 132.63} = 15.08 \text{ min}$$

$VTn = C$

$$T = \left(\frac{7}{5}\right)^{\frac{1}{0.25}} = 81 \text{ min / service}$$

$$\text{Number of workpiece} = \frac{81 \text{ min/ service}}{15.08 \text{ min/ piece}} = 5\frac{2}{5}\text{Pc/ser.}$$

The tool changing cost = 3 × 5 = ₹15

One tool produce 5 Pc., the tool changing cost per piece is

$$= \frac{15}{5} = ₹\ 3/\text{Pc.}$$

QUESTION-39 — NAT **(2 Marks)**

Ratio of solidification time of a cube casting and cylindrical casting _____ when cylindrical casting height is equal to diameter in identical conditions (Volume of castings are same) (Round off two decimal places).

SOLUTION: (0.84)

We know cylinder casting has D = H or 2r = H

Volume of cylinder = Volume of cube

$\pi r^2 h = a^3$

$\pi r^2 \times 2r = a^3$

$2\pi r^3 = a^3$

$r = 0.54a$

Now,

$$\frac{t_{cube}}{t_{cylinder}} = \frac{\left(\frac{V}{A_{cube}}\right)^2}{\left(\frac{V}{A_{cylinder}}\right)^2} = \left(\frac{A_{cylinder}}{A_{Cube}}\right)^2 = \left(\frac{6\pi r^2}{6a^2}\right)^2 = \left(\frac{\pi (0.54a)^2}{a^2}\right)^2 = 0.84$$

QUESTION-40 — MCQ **(2 Marks)**

Match the following.

P. Blind riser	(I) Casting with internal cavity
Q. Chill	(II) Molten metal cavity reservoir
R. Skim bob	(III) Nucleating agent
S. Core	(IV) Assisting in faster heat removal from melt
T. Insulating sleeve	(V) Removal of impurities
U. Inoculant	(VI) Increasing the solidification time.

(a) P-(II), Q-(VI), R-(V), S-(I), T-(IV), U-(III)

(b) P-(I), Q-(II), R-(III), S-(IV), T-(V), U-(VI)

(c) P-(II), Q-(IV), R-(III), S-(V), T-(I), U-(VI)

(d) P-(I), Q-(VI), R-(V), S-(III), T-(II), U-(IV)

SOLUTION: (a)

P. Blind riser	(II) Molten metal cavity reservoir
Q. Chill	(VI) Increasing the solidification time.
R. Skim bob	(V) Removal of impurities
S. Core T. Insulating sleeve U. Inoculant	(I) Casting with internal cavity (IV) Assisting in faster heat removal from melt (III) Nucleating agent

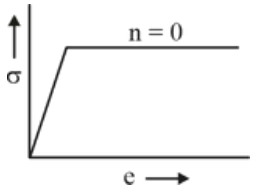
QUESTION-41 — MCQ **(2 Marks)**

Wire drawing operation is performed on a perfectly plastic metal without strain hardening. Assuming no friction and no redundant work, the maximum possible % reduction in a single pass.

(a) 75 (b) 63.2

(c) 93.2 (d) 51.2

SOLUTION: (b)



$$R = 1 - e^{-(n+1)} = 1 - e^{-1} = 1 - \frac{1}{e} = 0.632 = 63.2\%$$

QUESTION-42 — MCQ **(2 Marks)**

Match the following process for additive manufacturing:

Process		Layer creation technique		Material
P	Stereolithography	1.	Injection of powder stream	I. Paper
Q.	Fused deposition modeling	2.	Extrusion of melted polymer	II. Epoxy
R.	Laminated object manufacturing	3.	Liquid layer curing	III. Titanium
S.	Laser engineered net shaping	4.	Sheet metal deposition	IV. Acrylonitrile butadiene styrene (ABS)

(a) P-3, Q-2, R-4, S-

(c) 1 P-1, Q-4, R-2, S-3

(b) P-2, Q-4, R-3, S-

(d) 1 P-4, Q-3, R-2, S-1

SOLUTION: (a)

Process		Layer creation technique		Material
P	Stereolithography	3.	Liquid layer curing	II. Epoxy
Q.	Fused deposition modeling	2.	Extrusion of melted polymer	III. Titanium
R.	Laminated object manufacturing	4.	Sheet metal deposition	I. Paper
S.	Laser engineered net shaping	1.	Injection of powder stream	IV. Acrylonitrile butadiene styrene (ABS)

QUESTION-43 — MCQ **(2 Marks)**

The actual demand and forecast is given in the table. Determine mean forecast error and mean absolute deviation respectively.

Period	1	2	3	4	5	6	7	8	9	10
Actual demand	425	415	420	430	427	418	422	416	426	421
Forecast	427	422	416	422	423	420	419	418	430	415

(a) 0.8 and 4.2
(b) 8 and 4.2
(c) 0.8 and 42
(d) 8 and 42

SOLUTION: (a)

Period	1	2	3	4	5	6	7	8	9	10
Actual demand	425	415	420	430	427	418	422	416	426	421
Forecast	427	422	416	422	423	420	419	418	430	415
Di – Fi	-2	-7	4	8	4	-2	3	-2	-4	6

$$MAD = \frac{\sum_{i=1}^{n} |Di - Fi|}{n} = \frac{42}{10} = 4.2$$

$$MFE = \frac{\sum_{i=1}^{n} (Di - Fi)}{n} = \frac{25 - 17}{10} = 0.8$$

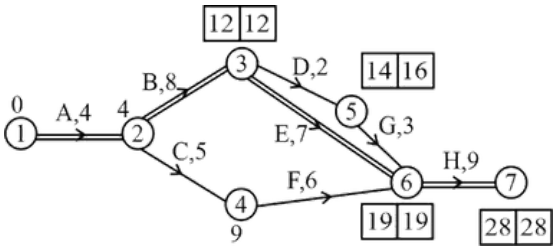
QUESTION-44 — NAT **(2 Marks)**

Activity, predecessor and duration are given in the table.

The slack of the activity D is _____ (in integer).

Activity	Immediate predecessor	Duration (hrs)
A	-	4
B	A	8
C	A	5
D	B	2
E	B	7
F	C	6
G	D	3
H	E, F, G	9

SOLUTION: (2)



Slack for activity D

EFT = Ei + te = 12 + 2 = 14

Slack or total float = LFT – EFT

= 16 – 14 = 2

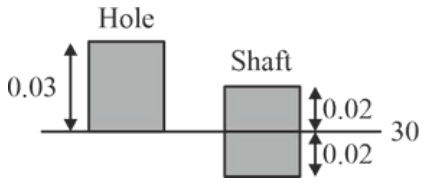
QUESTION-45 — MCQ **(1 Mark)**

In assembly hole size is $30^{+0.030}_{+0.000}$mm and shaft size is $30^{+0.020}_{-0.020}$mm. The assembly has

(a) Loose fit (b) Clearance fit

(c) Interference fit (d) Transition fit

SOLUTION: (d)



The tolerance zones have overlapped each other, so it is a transition fit.

QUESTION-46 —NAT **(1 Mark)**

A liquid metal is poured in a mold cavity of size = 200 × 200 × 200 mm3. Cooling is uniform in all direction with no additive compensation for shrinkage. Consider volumetric shrinkage = 7%. Solid shrinkage = 8%, during solidification, the length of cube edge after cooling down to room temperature is _____ mm (Round off two decimal places).

SOLUTION: (189.86)

$a^3 = (200)^3 \times \text{volumetric shrinkage} \times \text{Solid shrinkage}$

$a^3 = 2003 \times 0.93 \times 0.92$

$a = 189.86$ mm

SECTION-4	General Aptitude and Engineering Mathematics	General Aptitude Engineering Mathematics

QUESTION-47 — MCQ **(2 Mark)**

If two unbiased coins are tossed, then what is the probability of having at least one head?

(a) 0.7 (b) 0.675

(c) 5 (d) 0.5

0.2

5.

SOLUTION: (a)

P (getting at least one head) = 1 – P (getting no head) = 1 – P (both tail)

= 1 – P (TT) = 1 – $\frac{1}{2} \times \frac{1}{2} = \frac{3}{4}$

= 0.75 is

QUESTION-48 — NAT **(2 Marks)**

The values of a function f obtained for different values of x are shown in the table below

x	0	0.25	0.5	0.75	1.0
f(x)	0.9	2.0	1.5	1.8	0.4

Using Simpson 1/3rd rule

$\int_0^1 f(x)dx$ (round off to 2 decimal places)

SOLUTION: (1.625)

x	0	0.25	0.5	0.75	1.0
y = f(x)	0.9	2.0	1.5	1.8	0.4
	y0	y1	y2	y3	y4

h=0.25= $\frac{1}{4}$

$I = \int_0^1 f(x)dx = \frac{h}{3}[y0+y4+4(y1+y3)+2(y2)]$

$= \frac{1}{12}[0.9+0.4+4(2+1.8)+2(1.5)]$

$= \frac{1}{12}[1.3+4[3.8+3]$

$= \frac{1}{12}(1.3+15.2+3) = \frac{19.5}{12} = 1.625$

QUESTION-49 — MCQ **(1 Mark)**

Let A and B be real symmetric matrices of same size. Which one of the following options is correct

(a) AT = A–1 (b) AB = BA

(c) (AB)T = BTAT (d) A = A–1

SOLUTION: (c)

By reversal law (c) is true

QUESTION-50 — NAT **(2 Marks)**

Let y be the solution of the differential equation with the initial condition given below. if y(x =2) = A ln 2, then the value of A is ____ (Round off to two decimal places)

$x^2\frac{d^2y}{dx_2}+3x\frac{dy}{dx}+y=0$ $y\,(x=1)=0$ $\frac{dy}{dx}(x=1)=1$

SOLUTION: (0.5)

x2y'' + 3xy' + y = 0 _____ (1)

(D1(D1–1) + 3D1 + 1) y = 0

$(D21+2D1+1)y=0$ _____ (2)

AE : m2 + 2m +1 = 0 ⇒ m = –1, –1

$CF=(C1+C2z)e^{(}C1+C2\ln x^{1})$

$y=C1\left[\frac{1}{x}\right]+C2\left[\frac{\ln x}{x}\right]$ _____ (3)

$y'=\frac{-C1}{x2}+C_2\left[\frac{x\left[\frac{1}{x}\right]-\ln x}{x2}\right]$

$y'=\frac{-C_1}{x^2}+\frac{-C_2}{x^2}-C_2\left[\frac{\ln x}{x^2}\right]$

y (1) = 0 ⇒ 0 = C1 + 0 ⇒ C1 = 0

⇒ 1 = –C1 + C2 – 0 ⇒ C2 = 1

By (3),

$y=\frac{\ln x}{x}\Rightarrow y\,2(\,)=\frac{\ln 2}{2}$

$A=\frac{1}{2}=0.5$

QUESTION-51 — MCQ **(1 Mark)**

For the differential equation given below, which one is true?

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0 \quad \begin{matrix} 0 \le x \le 1, \\ 0 \le y \le 1 \end{matrix}$$

(a) u = sinx siny is a solution for all x and y

(b) u = cosx cosy is a solution for all x and y

(c) u = ex siny is a solution for all x and y

(d) u = ex+y is a solution for all x and y

SOLUTION: (c)

Using options, only C is satisfying given differential equation i.e. u = ex siny

$u_x = e^x \sin y$ and $u_{xx} = e^x \sin y$ _____ (1)

also $u_y = e^x \cos y$ and $u_{yy} = -e^x \sin y$ _____ (2)

Adding (1) and (2) we get uxx + uyy = 0 which is given differential equation

QUESTION-52 — MCQ **(1 Mark)**

The divergence of the curl of vector field is

(a) the argument of the vector field

(b) zero

(c) the magnitude of the curl of vector field

(d) the magnitude of this vector field

SOLUTION: (b)

By vector identity, we know that

divergence $(\text{curl}\vec{f}) = 0$

QUESTION-53 — NAT **(2 Marks)**

The directional derivative of the function given below at the point (1, 0) in the direction $\frac{1}{2}(\hat{i} + \sqrt{3}\hat{j})$ is ____

$f(x, y) = x^2 + xy^2$

SOLUTION: (1)

$$\vec{a} = \frac{\hat{i}}{2} + \frac{\sqrt{3}}{2}\hat{j}$$

$$\hat{a} = \frac{\vec{a}}{|\vec{a}|} = \frac{\frac{\hat{i}}{2} + \frac{\sqrt{3}}{2}\hat{j}}{\sqrt{1}}$$

$= \frac{1}{2}\hat{i} + \frac{\sqrt{3}}{2}\hat{j}$

Now grad $f = \vec{\nabla} f = i\,\frac{\partial f}{\partial x} + j\,\frac{\partial f}{\partial y} + k\,\frac{\partial f}{\partial z}$

$= \hat{i}(2x^2) + \hat{j}(2xy) + 0\hat{k}$

(grad f)P(1, 0) $= \hat{i}(2 + 0) + 0\hat{j} + 0\hat{k} = 2\hat{i}$

required D.D. $=$ grad $f \cdot \hat{a} = 2\hat{i} \cdot \left(\frac{1}{2}\hat{i} + \frac{\sqrt{3}}{2}\hat{j}\right) = 1$

QUESTION-54 — MCQ **(2 Marks)**

In the closed interval [0, 3] the minimum value of f(x) = 2x3 –9x2 + 12x is

(a) 4 (b) 9

(c) 0 (d) 5

SOLUTION: (c)

Given Data:

f(x) = 2x3 – 9x2 + 12x

f'(x) = 6x2 – 18x + 12 = 6 (x2 – 3x + 2)

= 6 (x – 1) (x – 2)

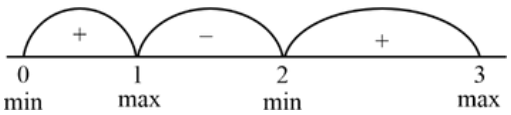
Turning points are x = 1 and 2

so minimum value occurs at x = 0 or 2

f(0) = (2x3 – 9x2 + 12x)x = 0 = 0

f(2) = (2x3 – 9x2 + 12x)x=2 = 16 – 36 + 24 = 4

so minimum value f (0) = 0



QUESTION-55 — NAT **(2 Marks)**

If C is the unit circle in the complex plane with its centre at origin. Then the value n in the equation given below is _____ (Round off to 1 decimal place)

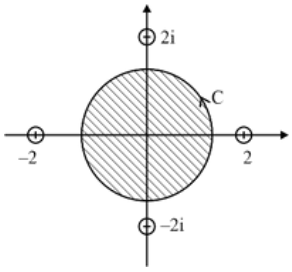
$$\oint_C \frac{z^3}{\left(z^2 + 4\right)\left(z^2 + 4\right)} dz = 2\pi i n$$

SOLUTION: (0)

$C: |z| = 1$ and $f(z) = \dfrac{z^3}{(z^2+4)(z^2-4)}$

poles of f(z) are; (z2 + 4) (z2 – 4) = 0

z=□2i&□2



∵ All the poles of f(z) lies outside the given contour C so by Cauchy integral theorem

$I = \oint_C f(z)dz = 0$ _____ (1)

But it is given that $I = \oint_C f(z)dz = 2\pi in$ _____ (2)

By (1) and (2) n=0

QUESTION-56 — MCQ **(2 Marks)**

If HIDE and CAGE are coded as 19-28-7-11 and 8-2-17-11 respectively. Then what is code for HIGH?

(a) 8-17-1-2
(b) 19-28-17-19
(c) 13-3-1-2
(d) 17-19-13-17

SOLUTION: (b)

HIDE → 1928-7-11 : CAGE 8-217-11

HIGH → 19-28-17-19

QUESTION-57 — MCQ **(1 Mark)**

The ceiling function of a real number x, denoted by Ce(x) is defined as the smallest integer that is greater than or equal to x. Similarly, the floor function denoted by fl(x) is defined as the largest integer that is smaller than or equal to x. Which one of the following statements is not correct for all possible value of x ?

(a) fl(x) < Ce(x)
(b) fl(x) □ (x)
(c) Ce(x) □ fl(x)
(d) Ce(x) □ x

SOLUTION: (a)

Given Data:

Floor function fl(x) ≤ x

and ceiling function Ce(x) ≥ x

Ce(x) − fl(x) is derived

fl(x) < Ce(x) → Incorrect as it can be equal to 0.

QUESTION-58 — MCQ **(1 Marks)**

P and Q play chess frequently against each other. Of these matches, P has won 80% of the matches, drawn 15% of the matches and lost 5% of the matches. If they play 3 more matches what is the probability of P winning exactly 2 of these 3 matches?

(a) 16/125 (b) 25/48

(c) 48/125 (d) 16/25

SOLUTION: (c)

$P(W) = \frac{16}{20}, P(D) = \frac{3}{20}, P(L) = \frac{1}{20}$

P winning exactly 2 of these 3 matches

LWW WLW WWL + DWW WDW WWD

$= {}^3C_1 \left(\frac{1}{20}\right)\left(\frac{16}{20}\right)^2 + {}^3C_1 \left(\frac{1}{20}\right)\left(\frac{16}{20}\right)^2 = \frac{48}{125}$

QUESTION-59 — MCQ **(1 Marks)**

Fish : Shoal : : Lion : _____

Select the correct option to complete the analogy

(a) series (b) forest

(c) school (d) pride

SOLUTION: (d)

Shoal: Group of fish swimming together

Pride: Group of lion

QUESTION-60 — MCQ **(2 Marks)**

Identify the option that has the most appropriate sequence such that a coherent paragraph is formed: (P) At once, without thinking much people rushed towards the city in hordes with the sole aim of grabbing as much gold as they could.

(Q) However, little did they realize about the impending hardships they could have to face on their way to the city : miles of mud, unfriendly forests hungry beasts and inimical local lords - all of which would reduce their chances of getting gold almost zero.

(R) All of them thought that easily they could lay their hands on gold and become wealthy overnight. About a hundred years ago, the news that gold had been discovered in Kolar

(S) spread like wild fire and the whole state was in raptures.

(a) S-P-R-Q
(b) Q-S-R-P
(c) S-Q-P-R
(d) P-Q-R-S

SOLUTION: (a)

Coherent paragraph is

About a hundred years ago, the news that gold had been discovered in Kolar spread like wild fire and the whole state was in raptures.

At once, without thinking much people rushed towards the city in hordes with the sole aim of grabbing as much gold as they could.

All of them thought that easily they could lay their hands on gold and become wealthy overnight.

However, little did they realize about the impending hardships they could have to face on their way to the city : miles of mud, unfriendly forests hungry beasts and inimical local lords - all of which would reduce their chances of getting gold almost zero.

QUESTION-61 — MCQ **(2 Marks)**

A final year student appears for placement interview in two company S and T. Based on her interviews performance, she estimates the probability of receiving job offers from company S and T to be 0.8 and 0.6 respectively. Let P be the probability that she receives job offers from both the companies. Select most appropriate option.

(a) $0.2 \leq P \leq 0.4$
(b) $0 \leq P \leq 0.2$
(c) $0.6 \leq P \leq 1.0$
(d) $0.4 \leq P \leq 0.6$

SOLUTION: (d)

P (getting job in S) = 0.8

P (getting job in T) = 0.6

P (getting job in both S and T) = P (getting job in S) × P (getting job in T)

= 0.8 × 0.6 = 0.48

Most appropriate option is $0.4 \leq P \leq 0.6$.

QUESTION-62 — MCQ **(1 Marks)**

Identify the grammatically correct

(a) It is I who are responsible for this fiasco

(b) It is myself who is responsible for this fiasco

(c) It is I who is responsible for this fiasco

(d) It is I who am responsible for this fiasco

SOLUTION: (d)

Grammatically correct sentence is

It is I who am responsible for this fiasco

QUESTION-63 — MCQ **(2 Marks)**

Which one of the following options has correct sequence of objects arranged in the increasing number of mirror lines (line of symmetric)?

(a) Isosceles triangle, equilateral triangle, square, circle

(b) Isosceles triangle, square, equilateral triangle, circle

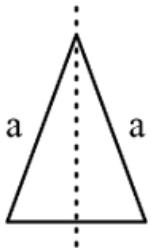
(c) Equilateral triangle, Isosceles triangle, square, circle

(d) Circle, square, equilateral triangle, isosceles triangle

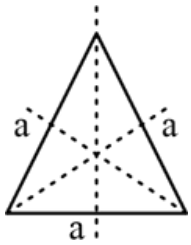
SOLUTION: (a)

No. of mirror lines for given shapes

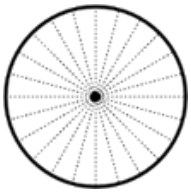
1. isosceles triangle → 1



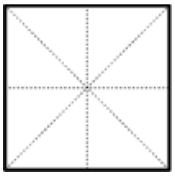
2. equilateral triangle→ 3



3. circle→ ∞



4. square→ 4



Increasing number of mirror lines

isosceles, equilateral, square, circle

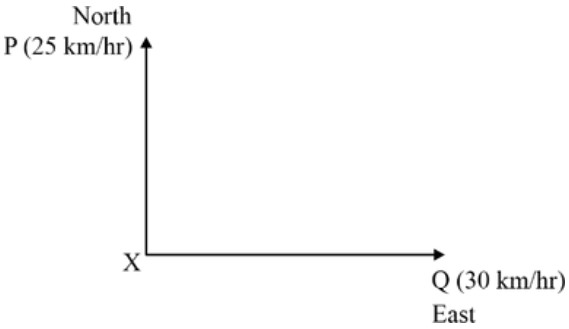
QUESTION-64 — MCQ **(1 Marks)**

Two cars P and Q starts from point X at 10 Am. Car P travels north with aspect of 25 km and car Q travels east with speed of 30 km/hr. car P travels continuously Q steps for same times after travelling for one hour. If both me ears are at the same distance from x at 11:30 pm for heaving (it minutes) did car d stop?

(a) 10 (b) 12

(c) 15 (d) 18

SOLUTION: (c)



At 11:30 AM distance travelled by P & Q are equal

Both started at 10:00 AM

Let 'x' be the no. of hours the car 'Q' stopped

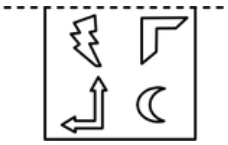
$$\left(25\left(\frac{3}{2}\right)\right)^2 = \left(30\left(1\frac{1}{2}\right) + 30(-x)\right)^2$$

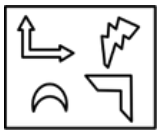
$\Rightarrow$ x = 0.25hrs

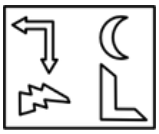
$\Rightarrow$ x = 15 minutes

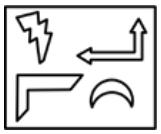
QUESTION-65 — MCQ **(2 Marks)**

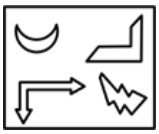
The given figure is reflected about the horizontal dashed line then rotated 90° clockwise about an axis perpendicular to the plane of the figure. Which of the following options correctly shows the resultant figure note figure shown on representation?



(a) 

(b) 

(c) 

(d) 

SOLUTION: (c)