2016 PAPER SET-I

Q.1-Q.5 carry one mark each.

Q1 Which of the following is **CORRECT** with respect to grammar and usage?
Mount Everest is ______.
(A) the highest peak in the world
(B) highest peak in the world
(C) one of highest peak in the world
(D) one of the highest peak in the world

S1 Correct option is (A)
Before superlative article 'the' has to be used. "one of" the expression should take plural noun and so option 'C' and 'D' can't be the answer.

Q2 The policeman asked the victim of a theft, "What did you ______?"
(A) loose
(B) lose
(C) loss
(D) louse

S1 Correct option is (B)
'lose' is verb

Q3 Despite the new medicine's ______ in treating diabetes, it is not ______ widely.
(A) effectiveness - prescribed
(B) availability - used
(C) prescription - available
(D) acceptance - proscribed

S1 Correct option is (A)
'effectiveness' is noun and 'prescribed' is verb. These words are apt and befitting with the word medicine'.

Q4 In a huge pile of apples and oranges, both ripe and unripe mixed together, 15% are unripe fruits. Of the unripe fruits, 45% are apples. Of the ripe ones, 66% are oranges. If the pile contains a total of 5692000 fruits, how many of them are apples?
(A) 2029198
(B) 2467482
(C) 2789080
(D) 3577422

S1 Correct option is (A)

$$\text{Total no. of fruits} = 5692000$$

$$= \frac{45}{100} \times \frac{15}{100} \times 5692000$$

$$= 384210$$

$$\text{Ripe type of apples} = \frac{34}{100} \times \frac{85}{100} \times 5692000$$

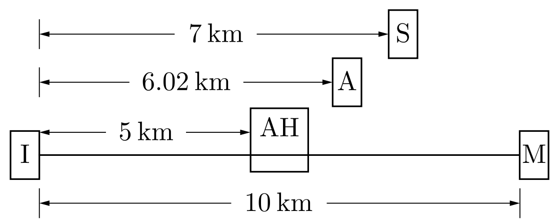
$$= 1644988$$

$$\therefore \quad \text{Total no. of apples} = 384210 + 1644988$$

$$= 2029198$$

Q5 Michael lives 10 km away from where I live. Ahmed lives 5 km away and Susan lives 7 km away from where I live. Arun is farther away than Ahmed but closer than Susan from where I live. From the information provided here, what is one possible distance (in km) at which I live from Arun's place?
(A) 3.00
(B) 4.99
(C) 6.02
(D) 7.01

S1 Correct option is (C)
From given data, the following diagram is possible

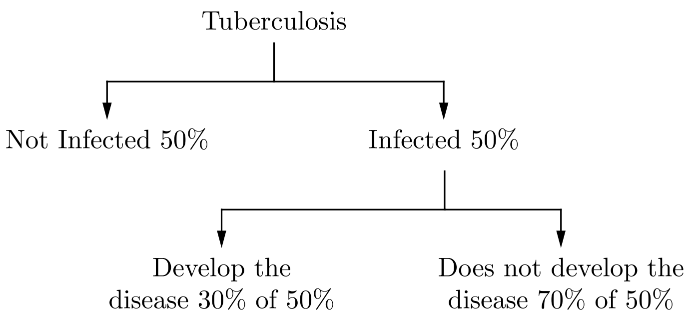


I = I live
AH = Ahmed lives
M = Michael lives
S = Susan lives
A = Arun lives

Q.6 to Q.10 carry two marks each.

Q6 A person moving through a tuberculosis prone zone has a 50% probability of becoming infected. However, only 30% of infected people develop the disease. What percentage of people moving through a tuberculosis prone zone remains infected but does not show symptoms of disease?
(A) 15
(B) 33
(C) 35
(D) 37

S1 Correct option is (C)



$$= \frac{70}{100} \times \frac{50}{100} \Rightarrow \frac{35}{100}$$
$$= 35\%$$

$\therefore$ Option 'C' is correct.

Q7 In a world filled with uncertainty, he was glad to have many good friends. He had always assisted them in times of need and was confident that they would reciprocate. However, the events of the last week proved him wrong. Which of the following inference(s) is/are logically valid and can be inferred from the above passage?

(i) His friends were always asking him to help him.

(ii) He felt that when in need of help, his friends would let him down.

(iii) He was sure that his friends would help him when in need.

(iv) His friends did not help him last week.

(A) (i) and (ii)

(B) (iii) and (iv)

(C) (iii) only

(D) (iv) only

S1 Correct option is (B)

The words 'was confident that they would reciprocate' and 'last week proved him wrong' lead to statements (iii) and (iv) as logically valid inferences.

Q8 Leela is older than her cousin Pavithra. Pavithra's brother Shiva is older than Leela. When Pavithra and Shiva are visiting Leela, all three like to play chess. Pavithra wins more often than Leela does.

Which one of the following statements must be True based on the above?

(A) When Shiva plays chess with Leela and Pavithra, he often loses.

(B) Leela is the oldest of the three.

(C) Shiva is a better chess player than Pavithra.

(D) Pavithra is the youngest of the three.

S1 Correct option is (D)

From given data, the following arrangement is possible.

Shiva

Leela

Pavithra

Among four alternatives, option (D) is TRUE.

Q9 if $q^{-a} = \frac{1}{r}$ and $r^{-b} = \frac{1}{s}$ and $S^{-c} = \frac{1}{q}$, the value of abc is ______

(A) $(rqs)^{-1}$

(B) 0

(C) 1

(D) $r + q + s$

S1 Correct option is (C)

$$\begin{aligned} q^{-a} &= \frac{1}{r} \Rightarrow \frac{1}{q^a} \\ &= \frac{1}{r} \Rightarrow q^a \\ &= r \\ r^{-b} &= \frac{1}{S} \Rightarrow \frac{1}{r^b} \\ &= \frac{1}{S} \Rightarrow S \\ &= r^b \\ S^{-c} &= \frac{1}{q} \Rightarrow \frac{1}{s^c} \\ &= \frac{1}{q} \Rightarrow S^c \\ &= q \\ q^a &= r \Rightarrow (S^c)^a \\ &= r \Rightarrow S^{ac} \\ &= r \\ (S^{ac})^b &= S \Rightarrow S^{abc} \\ &= S^1 \\ \therefore \quad abc &= 1 \end{aligned}$$

$\therefore$ Option (C) is correct.

Q10 P, Q, R and S are working on a project. Q can finish the task in 25 days, working alone for 12 hours a day. R can finish the task in 50 days, working alone for 12 hours per day. Q worked 12 hours a day but took sick leave in the beginning for two days. R worked 18 hours a day on all days. What is the ratio of work done by Q and R after 7 days from the start of the project?

(A) 10:11

(B) 11:10

(C) 20:21

(D) 21:20

S1 Correct option is (C)

$$\begin{aligned} Q \text{ can finish the task} &= 25 \text{ days, 12 hrs/day} \\ &= 300 \text{ hrs} \Rightarrow 1 \text{ hr} \\ &= \frac{1}{300}\text{th} \\ R \text{ can finish the task} &= 50 \text{ days, 12 hrs/day} \\ &= 50 \times 12 \\ &= 600 \text{ hrs} \Rightarrow 1 \text{ hr} \\ &= \frac{1}{600}\text{th} \\ Q \text{ Working hours} &\Rightarrow (7-2) \times 12 \\ &= 60 \text{ hrs} \\ R \text{ Working hours} &\Rightarrow 7 \times 18 \\ &= 126 \text{ hrs} \end{aligned}$$

After 7 days, the ratio of Work done by Q and R.

Q : R

$$\frac{60}{300} : \frac{126}{600}$$
$$20 : 21$$

Q.11-Q.35 carry one mark each.

Q11 The solution to the system of equation is
$$\begin{bmatrix} 2 & 5 \\ -4 & 3 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{Bmatrix} 2 \\ -30 \end{Bmatrix} \text{ is}$$
(A) 6, 2
(B) $-6, 2$
(C) $-6, -2$
(D) $6, -2$

S1 Correct option is (D)
$x = 6,\ y = -2$ is the solution of equation
$2x + 5y = 2$ and $-4x + 3y = -30$

Q12 If $f(t)$ is a function defined for all $t \geq 0$, its Laplace transform $F(s)$ is defined as
(A) $\int_0^\infty e^{st} f(t)\,dt$
(B) $\int_0^\infty e^{-st} f(t)\,dt$
(C) $\int_0^\infty e^{ist} f(t)\,dt$
(D) $\int_0^\infty e^{-ist} f(t)\,dt$

S1 Correct option is (B)
By the definition of Laplace transform of $f(t)\,\forall\, t \geq 0$, we have
$$F(s) = L\{f(t)\}$$
$$= \int_0^\infty e^{-st} f(t)\,dt$$

Q13 $f(z) = u(x,y) + iv(x,y)$ is an analytic function of complex variable $z = x + iy$ where $i = \sqrt{-1}$. If $u(x,y) = 2xy$, then $v(x,y)$ may be expressed as
(A) $-x^2 + y^2 +$ constant
(B) $x^2 - y^2 +$ constant
(C) $x^2 + y^2 +$ constant
(D) $-(x^2 + y^2) +$ constant

S1 Correct option is (A)
Given $u = 2xy,\ v = ?$
The Cauchy-Riemann equation
$u_x = v_y$ & $v_x = -u_y$
are satisfying with option (A) $-x^2 + y^2 +$ constant.
$\therefore$ $V(x,y) = -x^2 + y^2 +$ constant.

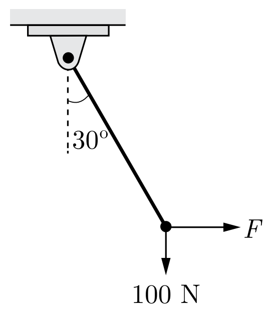
Q14 Consider a Poisson distribution for the tossing of a biased coin. The mean for this distribution is μ. The standard deviation for this distribution is given by
(A) μ
(B) μ^2
(C) μ
(D) $\frac{1}{\mu}$

S1 Correct option is (A)
For Poisson distribution mean=variance
Given mean $= \mu$
$\therefore$ Variance $= \mu$
$\therefore$standard deviation $= \sqrt{\mu}$

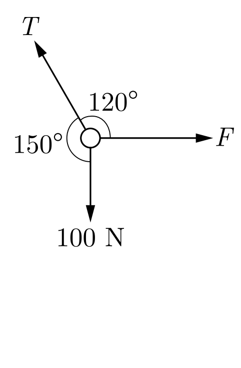
Q15 Solve the equation $x = 10\cos(x)$ using the Newton-Raphson method. The initial guess is $x = \frac{\pi}{4}$. The value of the predicted root after the first iteration, up to second decimal, is ______

S1 Correct answer is 1.564
Let $f(x) = x - 10\cos(x)$ & $X_0 = \left(\frac{\pi}{4}\right)$
Then $f'(x) = 1 + 10\sin(x)$
$$x_1 = x_0 - \frac{f(x_0)}{f(x_0)}$$
$$= \frac{\pi}{4} - \frac{\left(\frac{\pi}{4} - \frac{10}{\sqrt{2}}\right)}{\left(1 + \frac{10}{\sqrt{2}}\right)}$$
$$\Rightarrow \frac{\pi}{4} + \frac{(6.2857)}{(8.0711)}$$
$\therefore$ $x_1 = 1.5641$

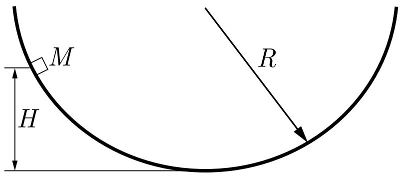
Q16 A rigid ball of weight 100 N is suspended with the help of a string. The ball is pulled by a horizontal force F such that the string makes an angle of 30° with the vertical. The magnitude of force F (in N) is ______



S1 Correct answer is 57.735 N
By Lami's theorem
$$\frac{F}{\sin 150^\circ} = \frac{100}{\sin 120^\circ} \Rightarrow 57.735 \text{ N}$$



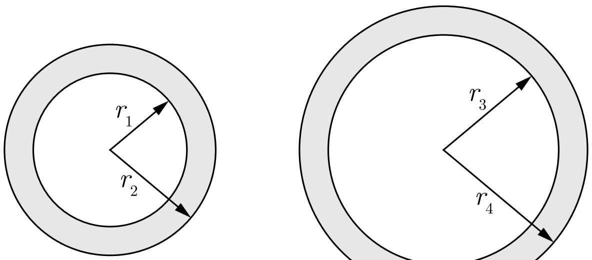
Q17 A point mass M is released from rest and slides down a spherical bowl (or radius R) from a height H as shown in the figure below. The surface of the bowl is smooth (no friction). The velocity of the mass at the bottom of the bowl is
(A) $\sqrt{gH}$
(B) $\sqrt{2gR}$
(C) $\sqrt{2gH}$
(D) 0



S1 Correct option is (C)
By Energy Conservation

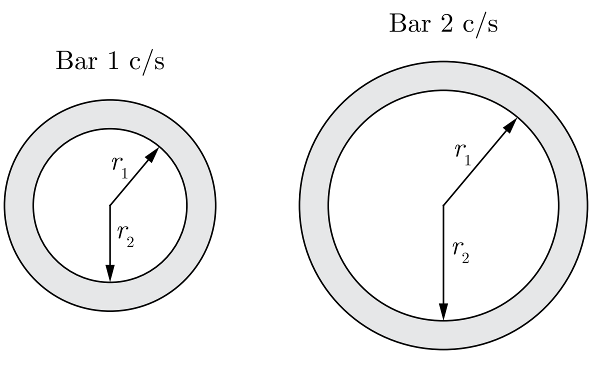
$$mgH = \frac{1}{2}mv^2$$
$$\Rightarrow V$$
$$= \sqrt{2gH}$$

Q18 The cross sections of two hollow bars made of the same material are concentric circles as shown in the figure. It is given that $r_3 > r_1$ and $r_4 > r_2$, and that the areas of the cross-sections are the same. J_1 and J_2 are the torsional rigidities of the bars on the left and right, respectively. The ratio $\frac{J_2}{J_1}$ is



(A) >1
(B) <0.5
(C) =1
(D) between 0.5 and 1

S1 Correct option is (A)



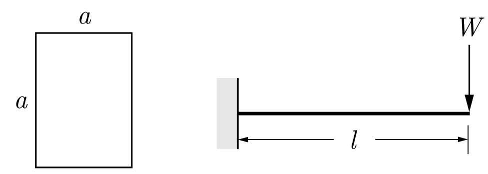
Given, $r_3 > r_1,\ r_4 > r_2$
$A_1 =$ Area of cross section of bar -1
$A_2 =$ Area of cross section of bar -2
$A_1 = A_2$

$$\Rightarrow [r_2^2 - r_1^2] = \pi[r_4^2 - r_3^2]$$
$$\therefore \quad r_2^2 - r_1^2 = r_4^2 - r_3^2 \Rightarrow r_3^2 - r_1^2$$
$$= r_4^2 - r_2^2$$
$$\therefore \quad \frac{J_2}{J_1} = \frac{\frac{\pi}{2}[r_4^4 - r_3^4]}{[r_2^4 - r_1^4]}$$
$$= \frac{(r_4^2 + r_3^2)(r_4^2 - r_3^2)}{(r_2^2 + r_1^2)(r_2^2 - r_1^2)}$$
$$= \frac{r_4^2 + r_3^2}{r_2^2 + r_1^2} \qquad [\therefore r_4^2 - r_3^2 = r_2^2 - r_1^2]$$
$$\frac{J_2}{J_1} > 1 \qquad [\therefore r_4 > r_2 \,\&\, r_3 > r_1]$$

Q19 A cantilever beam having square cross-section of side a is subjected to an end load. If a is increased by 19%, the tip deflection decrease approximately by
(A) 19%
(B) 29%
(C) 41%
(D) 50%

S1 Correct option is (D)

$$\delta_1 = \frac{W1^3}{3EI}$$
$$\frac{\delta_2}{\delta_1} = \frac{\left(\frac{a^4}{12}\right)}{\left(\frac{(1.19a)^4}{12}\right)}$$
$$= \frac{1}{(1.19)^4}$$
$$= 0.5$$



$$\delta_2 = 0.5(\delta_1)$$
δ_2 reduced by 50%

Q20 A car is moving on a curved horizontal road of radius 100 m with a speed of 20 m/s. The rotating masses of the engine have an angular speed of 100 rad/s in clockwise direction when viewed from the front of the car. The combined moment of inertia of the rotating masses is 10 kg-m^2. The magnitude of the gyroscopic moment (in N-m) is ______

S1 Correct answer is 200

$$R = 100 \text{ m},$$
$$v = 20 \text{ m/sec}$$
$$\omega_p = \frac{v}{R}$$
$$= 0.2\,\frac{\text{rad}}{\text{sec}}$$
$$\omega_s = 100 \text{ rad/sec}$$
$$I = 10\,\text{Kg - m}^2$$

Gyroscopic moment $I\omega_s\omega_p$
$= 10 \times 0.2 \times 100$ N-m
$= 200$ N-m

Q21 A single degree of freedom spring mass system with viscous damping has a spring constant of 10 kN/m. The system is excited by a sinusoidal force of amplitude 100 N. If the damping factor (ratio) is 0.25, the amplitude of steady state oscillation at resonance is ______ mm.

S1 Correct answer is 20

$$k = 10 \text{ kN/m}$$
$$F_0 = 100 \text{ N}$$
$$\xi = 0.25$$
$$X = \frac{\left(\frac{F_0}{k}\right)}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2 + \left(2\xi\frac{\omega}{\omega_n}\right)^2}}$$
$$\frac{\omega}{\omega_n} = 1 \text{ at resonance}$$
$$X = \frac{F_0}{2k\xi}$$
$$= \frac{100}{2 \times 10 \times 0.25 \times 10^3}$$
$$= 20 \text{ mm}$$

Q22 The spring constant of a helical compression spring DOES NOT depend on
(A) coil diameter
(B) material strength
(C) number of active turns
(D) wire diameter

S1 Correct option is (B)

Q23 The instantaneous stream-wise velocity of a turbulent flow is given as follows:
$u(x,y,z,t)\overline{u}(x,y,z)\ u'(x,y,z,t)$
The time-average of the fluctuating velocity $u'(x,y,z,t)$ is
(A) $\frac{u'}{2}$
(B) $-\frac{\overline{u}}{2}$
(C) zero
(D) $\frac{\overline{u}}{2}$

S1 Correct option is (C)
Time average of fluctuating velocity is zero.

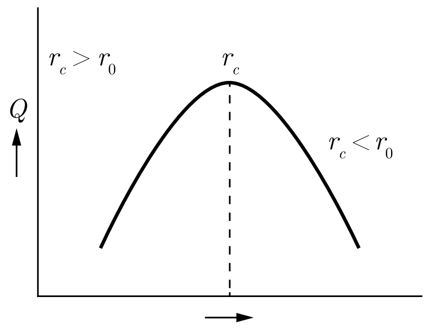
Q24 For a floating body, buoyant force acts at the
(A) centroid of the floating body
(B) center of gravity of the body
(C) centroid of the fluid vertically below the body
(D) centroid of the displaced fluid.

S1 Correct option is (D)
For floating body Buoyancy force acts through the centre of buoyancy which is C.G. for displaced volume.

Q25 A plastic sleeve of outer radius $r_0 = 1$ mm covers a wire (radius $r = 0.5$ mm) carrying electric current. Thermal conductivity of the plastic is 0.15 W/m-K. The heat transfer coefficient on the outer surface of the sleeve exposed to air is 25 W/m^2-K. Due to the addition of the plastic cover, the heat transfer from the wire to the ambient will
(A) increase
(B) remain the same
(C) decrease
(D) be zero

S1 Correct option is (A)

$$r_0 = 1 \text{ mm},$$
$$k = 0.15 \text{ W/m-K}$$
$$h = 25 \text{ W/m}^2\text{-K}$$
$$r_c = \frac{k}{h_0} \text{ for cylindrical shape}$$
$$= \frac{0.15}{25} \times 1000$$
$$= 0.15 \times 40$$
$$= 6 \text{ mm}$$



$\therefore$ $r_c > r_0 \Rightarrow$ The heat transfer from the wire to the ambient will increase.

Q26 Which of the following statements are TRUE with respect to heat and work?
(i) They are boundary phenomena
(ii) They are exact differentials
(iii) They are path functions
(A) both (i) and (ii)
(B) both (i) and (iii)
(C) both (ii) and (iii)
(D) only (iii)

S1 Correct option is (B)

Q27 Propane (C_3H_8) is burned in an oxygen atmosphere with 10% deficit oxygen with respect to the stoichiometric requirement. Assuming no hydrocarbons in the products, the volume percentage of CO in the products is ______

S1 Correct answer is 14.29%

$$C_3H_8 + xO_2 \rightarrow aCO_2 + bH_2O$$

Carbon balance

$$a = 3$$

Hydrogen balance:

$$2b\ 8 \rightarrow b = 4$$

Oxygen balance:

$$2x = 2a + b$$
$$\rightarrow x = a + \frac{b}{2} = 3 + \frac{4}{2} = 5$$

For chemically correct or stoichiometric burning, no. of moles of O_2 required are $= 5$.

As it is burnt with 10% deficient oxygen, it will generate CO.

The new equation is

$$C_3H_8 + 0.9 \times 5O_2 \rightarrow aCO_2 + bCO + cH_2O$$

Carbon balance:

$$a + b = 3$$

Hydrogen balance:

$$2c = 8 \rightarrow c = 4$$

Oxygen balance:

$$2a + b + c = 0.9 \times 5 \times 2 = 9$$
$$2a + b + c = 9$$
$$\Rightarrow 2a + b + 4 = 9 \Rightarrow 2a + b = 5 \quad ...(i)$$
$$a + b = 3 \quad ...(ii)$$

By solving (i) & (ii)

$$a = 2 \ \& \ b = 1$$

In the exhaust products the no. of moles of CO are 1.% by volume of CO in exhaust.

$$= \frac{b}{a+b+c} \times 100 = \frac{1}{2+1+4} \times 100 = \frac{1}{7} \times 100 = 14.29\%$$

Q28 Consider two hydraulic turbines having identical specific speed and effective head at the inlet. If the speed ratio $\left(\frac{N_1}{N_2}\right)$ of the two turbines is 2, then the respective power ratio $\left(\frac{P_1}{P_2}\right)$ is ______

S1 Correct answer is 0.25

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

Given $N_{si} = N_{s2} = H_1 = H_2$

$$\frac{N_1}{N_2} = 2, \ \frac{P_1}{P_2} = ?$$

$$N_1\sqrt{P_1} = N_2\sqrt{P_2} \Rightarrow \frac{P_1}{P_2} = \left[\frac{N_2}{N_1}\right]^2 = \left(\frac{1}{2}\right)^2 = 0.25$$

Q29 The INCORRECT statement about regeneration in vapor power cycle is that

(A) it increase the irreversibility by adding the liquid with higher energy content to the steam generator

(B) heat is exchanged between the expanding fluid in the turbine and the compressed fluid before heat addition

(C) the principle is similar to the principle of Stirling gas cycle

(D) it is practically implemented by providing feed water heaters.

S1 Correct option is (C)

Q30 The "Jominy test" is used to find

(A) Young's modulus

(B) hardenability

(C) yield strength

(D) thermal conductivity

S1 Correct option is (B)

The depth upto which the required hardness is obtained is called as hardenability and it is determined by using jomney end quench test.

Q31 Under optimal conditions of the process the temperatures experienced by a copper work piece infusion welding, brazing and soldering are such that

(A) $T_{welding} > T_{soldering} > T_{brazing}$

(B) $T_{soldering} > T_{welding} > T_{brazing}$

(C) $T_{brazing} > T_{welding} > T_{soldering}$

(D) $T_{welding} > T_{brazing} > T_{soldering}$

S1 Correct option is (D)

In welding (Fusion welding for melting the parent material the temperature should be greater than the MP of the metal hence it is high. Whereas brazing and soldering are the nonfusion welding operations hence the temperature should be less than the MP of the metal. Brazing temp is above 427°C and soldering is below 427°C.

Q32 The part of a gating system which regulates the rate of pouring of molten metal is

(A) Pouring basin

(B) runner

(C) choke

(D) ingate

S1 Correct option is (C)

Rate of pouring of molten metal depends on the flow rate of molten metal. This depends on the choke area and it is the minimum area out of the cross sectional areas of sprue, runner and ingate.

Q33 The non-traditional machining process that essentially requires vacuum is
(A) electron beam machining
(B) electro chemical machining
(C) electro chemical discharge machining
(D) electro discharge machining

S1 Correct option is (A)
Electron beam machining is the only method carried out under vacuum, to avoid the dispersion of electrons after the magnetic deflector.

Q34 In an orthogonal cutting process the tool used has rake angle of zero degree. The measured cutting force and thrust force are 500 N and 250 N, respectively. The coefficient of friction between the tool and the chip is ______.

S1 Correct answer is 0.5
Because the rake angle is zero,

$$F = \text{Friction force}$$
$$F_c = \text{cutting force} = 500\text{ N},$$
$$N = \text{Normal to friction force}$$
$$F_t = \text{Thrust force} = 250\text{ N}$$
$$\text{Coefficient of friction} = \frac{F}{N} = \frac{250}{500} = 0.5$$

Q35 Match the following:

P.	Feeler gauge	I.	Radius of an object
Q.	Fillet gauge	II.	Diameter within limits by comparison
R.	Snap gauge	III.	Clearance or gap between components
S.	Cylindrical plug gauge	IV.	Inside diameter of straight hole

(A) P-III, Q-I, R-II, S-IV
(B) P-III, Q-II, R-I, S-IV
(C) P-IV, Q-II, R-I, S-III
(D) P-IV, Q-I, R-II, S-III

S1 Correct option is (A)
Feeler gauge is used for checking the clearance or gap between the parts, radius is checked by fillet gauge, limits of diameter of shaft is checked by snap gauge and plug gauge is used for checking the diameter of hole.

Q.36-Q.65 carry two marks each.

Q36 Consider the function $(x) = 2x^3 - 3x^2$ in the domain $[-1,2]$. The global minimum of $f(x)$ is ______

S1 Correct answer is -5

$$f(x) = 2x^3 - 3x^2 \text{ in } [-1,2]$$
$$f'(x) = 0 \Rightarrow 6x^2 - 6x = 0$$
$$6x(x-1) = 0$$
$$X = 0 \;\&\; 1$$
$$F(-1) = -5,$$
$$f(1) = -1$$
$$f(2) = 4$$
$$\text{Global minimum} = -5$$

Q37 If $y = (x)$ satisfies the boundary value problem $y'' + 9y = 0$, $y(0) = 0$, $y(\pi/2) = \sqrt{2}$, they $y(\pi/4)$ is ______

S1 Correct answer is -1

$$y'' + 9y = 0$$

A.E. is $m^2 + 9 = 0$

$$M \pm 3i$$
$$Y = y_c + Y_p$$
$$Y = C_1 \cos 3x + C_2 \sin 3x \quad \text{...(i)}$$
$$(\therefore \; Y_p = 0)$$

If $x = 0,\ y = 0$

(1) $0 = C_1(1) + C_2(0) \Rightarrow C_1 = 0$

If $x = \frac{\pi}{2}\ y = \sqrt{2}$

(2) $\sqrt{2} = C_1(0) + C_2 \sin\left(\frac{3\pi}{2}\right) = C_2(-1)$

$\therefore$ $Y = -\sqrt{2}\sin 3x$

If $x = \frac{\pi}{4}$

$$Y\left(\frac{\pi}{4}\right) = -\sqrt{2}\sin\left(\frac{3\pi}{4}\right) = -\sqrt{2}\left(\frac{1}{\sqrt{2}}\right) = -1$$

Q38 The value of the integral

$$\int_{-\infty}^{\infty} \frac{\sin x}{x^2 + 2x + 2} dx$$

evaluated using contour integration and the residue theorem is
(A) $-\frac{\pi \sin(1)}{e}$
(B) $-\frac{\pi \cos(1)}{e}$
(C) $\frac{\sin(1)}{e}$
(D) $\frac{\cos(1)}{e}$

S1 Correct option is (A)

$$I \int_{-\infty}^{\infty} \frac{\sin(x)}{x^2 + 2x + 2} dx$$

Let $f(z) = \frac{I_m(e^{iz})}{Z^2+2z+2}$

Then poles of $f(z)$ are given by

$$z^2+2z+2 = 0$$

$$\therefore \quad z = -1 \pm i$$

$$R_1 = \text{Res}(f(z): z = -1+i)$$

$$= \lim_{z \to 1+i} \frac{e^{iz}}{[z-(-1+i)][z-(-1-i)]}$$

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

$$= \frac{e^{-i-1}}{2i}$$

$$\int_c f(z)\,dz = \int_c \frac{I_{m(e^{iz})}}{z^2+2z+2}dz$$

$$= I_m[2\pi i(R_1)]$$

$$= I_m\left[2\pi i\left(\frac{e^{-i-1}}{2i}\right)\right]$$

$$= I_m[\pi e^{-1}(\cos(1) - i\sin(1))]$$

$$= -\frac{\pi\sin(1)}{e}$$

Q39 Gauss-Seidel method is used to solve the following equation (as per the given order):

$$x_1 + 2x_2 + 3x_3 = 5$$
$$2x_1 + 3x_2 + x_3 = 1$$
$$3x_1 + 2x_2 + x_3 = 3$$

Assuming initial guess as $x_1 = x_2 = x_3 = 0$, the value of x_3 after the first iteration is ______

S1 Correct answer is -6

Let $x+2y+3z = 5$

$$2x+3y+z = 1$$

$$3x+2y+z = 3 \text{ and } x_0 = 0,\ y_0 = 0,\ z_0 = 0$$

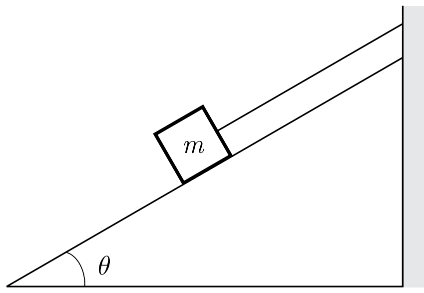
Then first iteration will be

$$x_1 = x_1$$
$$= 5 - 2y_0 - 3z_0$$
$$= 5 - 0 - 0$$
$$= 5$$
$$x_2 = y_1$$
$$= \frac{1}{3}(1 - 2x_1 - z_0)$$
$$= \frac{1}{3}(1 - 10 - 0)$$
$$= -3$$
$$X_3 = z_1$$
$$= 3 - 3x_1 - 2y_1$$
$$= 3 - 15 + 6$$
$$= -6$$
$$\therefore \quad x_3 = -6$$

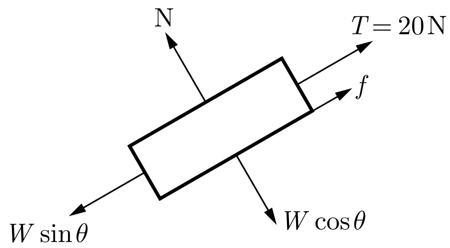
Q40 A block of mass m rests on an inclined plane and is attached by a string to the wall as shown in the figure. The coefficient of static friction between the plane and the block is 0.25. The string can withstand a maximum force of 20 N. The maximum value of the mass (m) for which the string will not break and the block will be in static equilibrium is ______ kg.

Take $\cos\theta = 0.8$ and $\sin\theta = 0.6$.

Acceleration due to gravity $g = 10\ \text{m/s}^2$

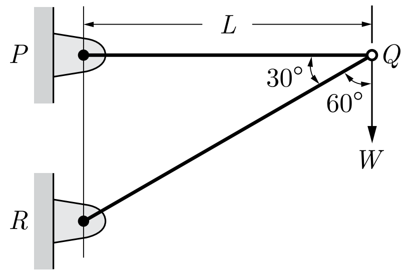


S1 Correct answer is 5



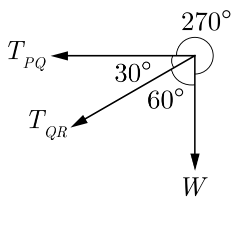
$$\sum F_Y = 0$$
$$\Rightarrow \quad = N = W\cos\theta$$
$$= 0.8W$$
$$f = \mu N$$
$$0.2W$$
$$\sum F_X = 0$$
$$\Rightarrow \quad 0.6W = 20 + 0.2W$$
$$\Rightarrow \quad W = 50 \text{ N}$$
$$\Rightarrow \quad m = 5 \text{ kg}$$

Q41 A two-member truss PQR is supporting a load W. The axial force in members PQ and QR are respectively



(A) $2W$ tensile and $\sqrt{3}\,W$ compressive
(B) $\sqrt{3}\,W$ tensile and $2W$ compressive
(C) $\sqrt{3}\,W$ compressive and $2W$ tensile
(D) $2W$ compressive and $\sqrt{3}\,W$ tensile

S1 Correct option is (B)



By Lami's theorem

$$\frac{W}{\sin 30} = \frac{T_{PQ}}{\sin 60}$$

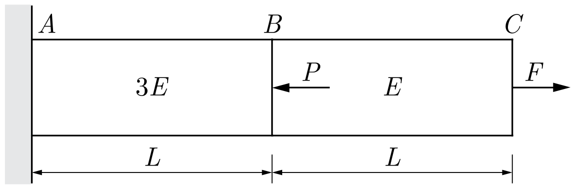
$$= \frac{T_{QR}}{\sin 270}$$

$$\Rightarrow \quad T_{PQ} = \sqrt{3}\, W(T)$$

$$\Rightarrow \quad T_{QR} = -2W$$

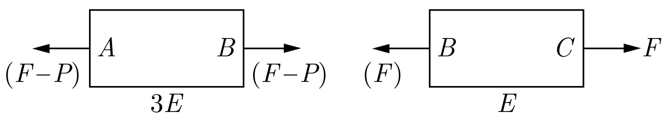
$$= 2W(C)$$

Q42 A horizontal bar with a constant cross-section is subjected to loading as shown in the figure. The Young's moduli for the sections AB and BC are $3E$ and E, respectively.



For the deflection at C to be zero, the ratio $\frac{P}{F}$ is ______

S1 Correct answer is 4



$$\delta_{AB} + \delta_{BC} = 0$$

$$\frac{(F-P)L}{A(3E)} + \frac{(F)(L)}{(A)(E)} = 0$$

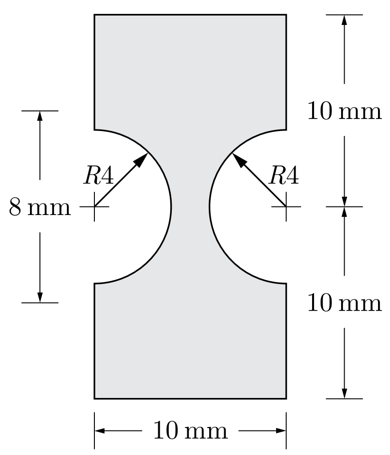
$$\frac{(F-P)}{3} + F = 0$$

$$F - P + 3F = 0$$

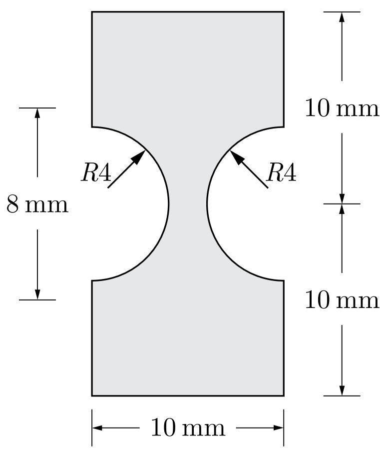
$$4F = P$$

$$\frac{P}{F} = 4$$

Q43 The figure shows cross-section of a beam subjected to bending. The area moment of inertia (in mm^4) of this cross-section about its base is ______



S1 Correct answer is 21439.07



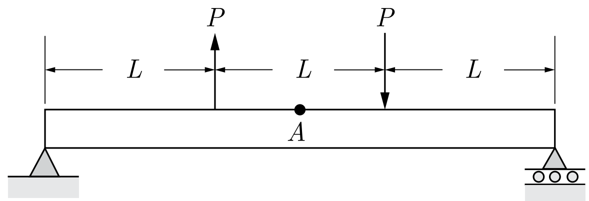
$$I = \frac{10 \times 20^3}{12} + 10 \times 20(10)^2$$

$$-\left[\frac{\pi}{64} \times (8)^4 + \frac{\pi}{4} \times (8^2)(10)^2\right]$$

$$= 26666.67 - 5227.6$$

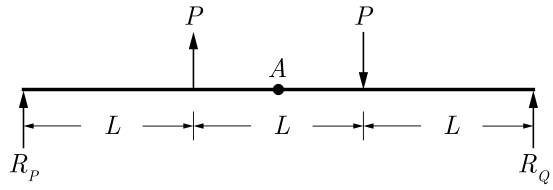
$$= 21439.07 \text{ mm}^4$$

Q44 A simply-supported beam of length $3L$ is subjected to the loading shown in the figure.



It is given that $P = 1$ N, $L = 1$ m and Young's modulus $E = 200$ GPa. The cross-section is a square with dimension 10 mm × 10 mm. The bending stress (in Pa) at the point A located at the top surface of the beam at a distance of 1.5 L from the left and is ______
(Indicate compressive stress by a negative sign and tensile stress by a positive sign.)

S1 Correct answer is zero.



$$-R_Q(3L) + P(2L) - P(L) = 0$$

$$R_Q(3L) = P(L)$$

$$R_Q = +\frac{P}{3}$$

$$M_A = R_Q(1.5L) - P(0.5L)$$

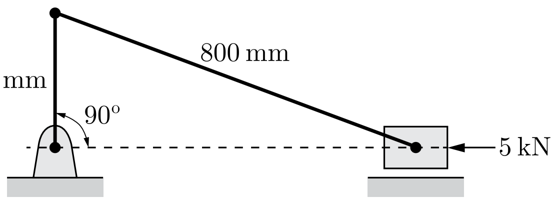
$$\Rightarrow \frac{P}{3}\left(\frac{3}{2}L\right) - \frac{P}{2}L$$

$$M_A = 0 \Rightarrow \sigma_A$$

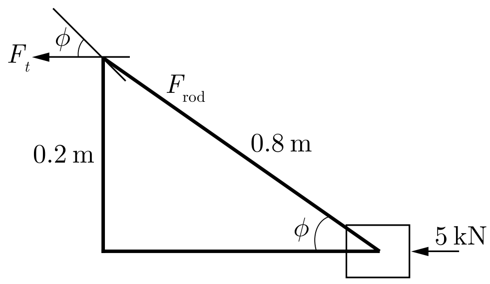
$$= 0 \ [\because \sigma \propto M]$$

Q45 A slider crank mechanism with crank radius 200 mm and connecting rod length 800 mm is shown. The crank is rotating at 600 rpm in the counter clockwise direction. In the configuration shown, the crank makes an angle of 90° with the sliding direction of the slider, and a force of

5 kN is acting on the slider. Neglecting the inertia forces, the turning moment on the crank (in kN-m) is ______



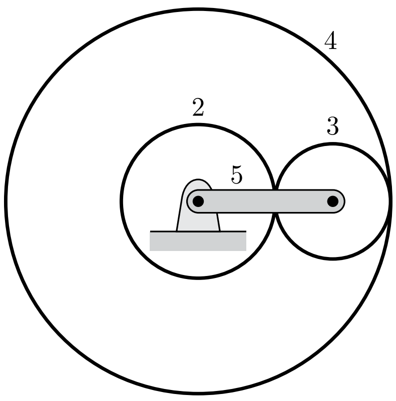
S1 Correct answer is 1



Given

$$
\begin{aligned}
F_p &= 5 \text{ kN} \\
F_{\text{rod}} &= \frac{F_p}{\cos\phi}, \\
F_t &= F_{rod}\cos\phi \\
\therefore \quad F_t &= 5 \text{ kN} \\
\text{Turning moment} &= F_t \cdot r \\
&= 5 \times 0.2 \\
&= 1 \text{ kN-m}
\end{aligned}
$$

Q46 In the gear train shown, gear 3 is carried on arm 5. Gear 3 meshes with gear 2 and gear 4. The number of teeth on gear 2, 3 and 4 are 60, 20 and 100 respectively. If gear 2 is fixed and gear 4 rotates with an angular velocity of 100 rpm in the counterclockwise direction, the angular speed of arm 5 (in rpm) is



(A) 166.7 counterclockwise
(B) 166.7 clockwise
(C) 62.5 counterclockwise
(D) 62.5 clockwise

S1 Correct option is (C)

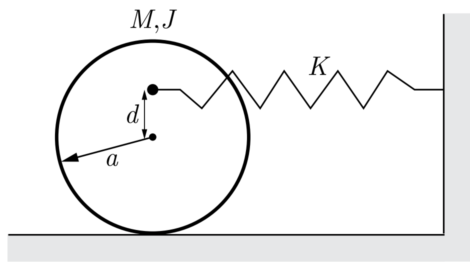
Given

$$
\begin{aligned}
T_2 &= 60 \\
N_2 &= 0 \\
T_3 &= 20 \\
T_4 &= 100 \\
N_4 &= 100 \text{ rpm (ccw+ve)}
\end{aligned}
$$

Relative velocity equation

$$
\begin{aligned}
\frac{N_4 - N_a}{N_2 - N_a} &= -\frac{T_2}{T_4} \\
&= \frac{100 - N_a}{0 - N_a} \\
&= \frac{-60}{100} \\
1.6\ N_a &= 100 \\
N_a &= \frac{100}{1.6} \\
&= 62.5 \text{ rpm (ccw)}
\end{aligned}
$$

Q47 A solid disc with radius a is connected to a spring at a point d above the center of the disc. The other end of the spring is fixed to the vertical wall. The disc is free to roll without slipping on the ground. The mass of the disc is M and the spring constant is K. The polar moment of inertia for the disc about its centre is $J = \frac{ma^2}{2}$.



The natural frequency of this system in rad/s is given by

(A) $\sqrt{\frac{2K(a+d)^2}{3Ma^2}}$

(B) $\sqrt{\frac{2K}{2M}}$

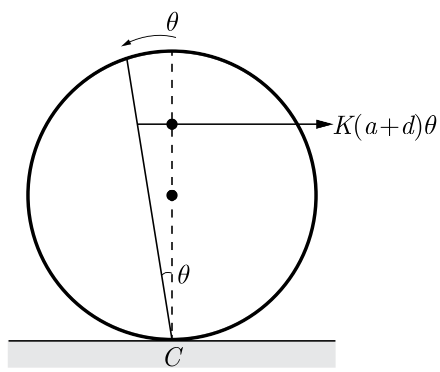
(C) $\sqrt{\frac{2K(a+d)^2}{Ma^2}}$

(D) $\sqrt{\frac{K(a+d)^2}{Ma^2}}$

S1 Correct option is (A)

Moment equilibrium above instantaneous centre (contact point)

$$-K(a+d)\theta \cdot (a+d) = I_c\overline{\theta}$$



$$
\begin{aligned}
I_c &= \frac{3}{2}ma^2, \\
\omega_n &= \sqrt{\frac{K(a+d)^2}{\frac{3}{2}ma^2}} \\
\omega_n &= \sqrt{\frac{2K(a+d)^2}{3ma^2}}
\end{aligned}
$$

Q48 The principal stresses at a point inside a solid object are $\sigma_1 = 100$ MPa, $\sigma_2 = 100$ MPa and $\sigma_3 = 0$ MPa. The yield strength of the material is 200 MPa. The factor of safety calculated using Tresca (maximum shear stress) theory is n_T and the factor of safety calculated using von Mises (maximum distortional energy) theory is n_V. Which one of the following relations is TRUE?

(A) $n_T = \left(\frac{\sqrt{3}}{2}\right) n_V$

(B) $n_T = (\sqrt{3}) n_V$

(C) $n_T = n_V$

(D) $n_V = (\sqrt{3}) n_T$

S1 Correct option is (C)

According to maximum shear stress theory

$$\sigma_1 - \sigma_2 = \frac{S_{yt}}{n_T}$$

$$\Rightarrow = \frac{200}{100} = 2$$

According to Distortion Energy theory

$$\sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2} = \frac{S_{yt}}{n_V}$$

But $\sigma_1 = \sigma_2$, let it is σ_1

$$\sqrt{\sigma_1^2 + \sigma_1^2 - \sigma_1^2} = \frac{S_{yt}}{n_V} \Rightarrow n_V = \frac{S_{yt}}{\sigma_1} - \frac{200}{100}$$

$$= 2$$

$$\therefore \qquad n_T = n_V$$

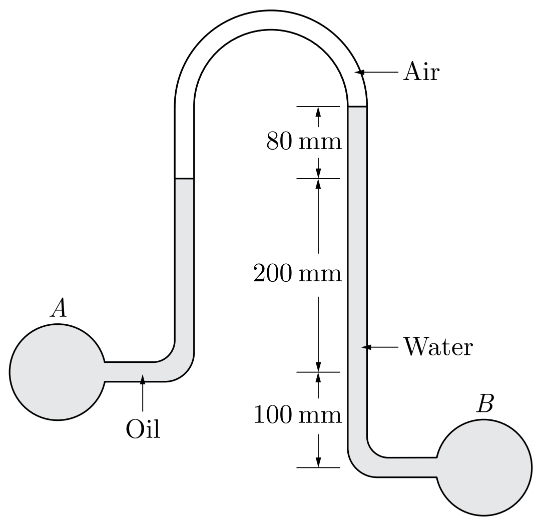
Q49 An inverted U-tube manometer is used to measure the pressure difference between two pipes A and B, as shown in the figure. Pipe A is carrying oil (specific gravity = 0.8) and pipe B is carrying water. The densities of air and water are $1.16\,\text{kg/m}^3$ and $1000\,\text{kg/m}^3$, respectively. The pressure difference between pipes A and B is ______ kPa.

S1 Correct answer is -2.2

$$P_A - (\rho_{oil} \times g \times 0.2) - (\rho_{air} \times g \times 0.08) + (\rho_\omega g \times 0.38) - P_B = 0$$

$$P_A - P_B = -2.2 \text{ kPa}$$

Acceleration due to gravity $g = 10\,\text{m/s}^2$



Q50 Oil (kinematic viscosity, voil $= 1.0 \times 10^{-5}\,\text{m}^2/\text{s}$) flows through a pipe of 0.5 m diameter with a velocity of 10 m/s. Water (kinematic viscosity, $v_w = 0.89 \times 10^{-6}\,\text{m}^2/\text{s}$) is flowing through a model pipe of diameter 20 mm. For satisfying the dynamic similarly, the velocity of water (in m/s) is

S1 Correct answer is 22.25

Oil	**Water**
$v = 1.0 \times 10^{-5}\,\text{m}^2/\text{s}$	$v = 0.89 \times 10^{-6}\,\text{m}^2/\text{s}$
$d = 0.5$ m	$d = 0.02$ m,
$v = 10$ m/sec	$v = ?$

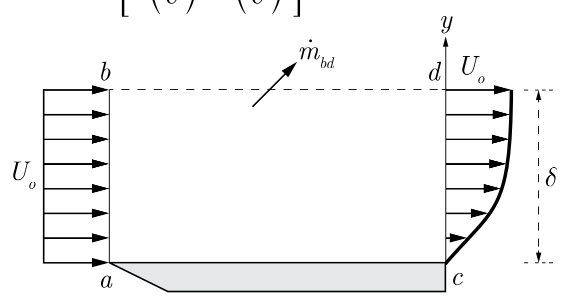
$$[R_e]_{(\text{oil})} = [R_e]_\omega$$

$$\frac{10 \times 0.5}{1.0 \times 10^{-5}} = \frac{V \times 0.02}{0.89 \times 10^{-6}}$$

$$\Rightarrow \qquad V = 22.25 \text{ m/s}$$

Q51 A steady laminar boundary layer is formed over a flat plate as shown in the figure. The free stream velocity of the fluid is U_0. The velocity profile at the inlet $a - b$ is uniform, while that at a downstream location $c - d$ is given by

$$u\ U_0\left[2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2\right]$$



The ratio of the mass flow rate, m_{bd}, leaving through the horizontal section b - d to that entering through the vertical section $a - b$ is ______

S1 Correct answer is 0.33

mass entering = mass leaving

$$\dot{m}_{bd} = \dot{m}_{bd} + \int_0^\delta \rho dy \qquad \text{...(1)}$$

$$\int_0^\delta u dy = u_0 \int_0^\delta 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

$$= u_0 \left[\frac{y^2}{\delta} - \frac{-y^3}{3\delta^2}\right]_0^\delta$$

$$= u_0 \left[\delta - \frac{\delta}{3}\right]$$

$$\int_0^\delta u dy = \frac{2}{3} u_0 p \delta \qquad \text{...(2)}$$

Substituting (2) in 1

$$\dot{m}_{(ba)} = \dot{m}_{(bd)} + \frac{2}{3} u_0 \delta$$

$$\rho u_0 \delta = \frac{\dot{m}_{(bd)}}{\dot{m}_{ba}} + \frac{\frac{2}{3u_0\delta p}}{\rho u_0 \delta}$$

$$\therefore \qquad \frac{\dot{m}_{bd}}{\dot{m}_{ba}} = 1 - \frac{2}{3}$$

$$= \frac{1}{3}$$

Q52 A steel ball of 10 mm diameter at 1000 K is required to be cooled to 350 K by immersing it in a water environment at 300 K. The convective heat transfer coefficient is 1000 W/m^2-K. Thermal conductivity of steel is 40 W/m-K. The time constant for the cooling process τ is 16 s. The time required (in s) to reach the final temperature is ______

S1 Correct answer is 42.22 sec

$$\text{Biot number} = \frac{hL_c}{K}$$

For sphere
$$L_c = \frac{\text{Volume}}{\text{surface area}} = \frac{d}{6}$$

$$\therefore \quad Bi = \frac{hd}{6k} = \frac{1000 \times 0.01}{6 \times 40} = 0.0416 < 0.1$$

Hence lumped heat analysis is used.

$$\frac{T - T_\infty}{T_i - T_\infty} = \frac{-hA_s t}{e^{\rho VCp}} = \frac{-t}{et^*}$$

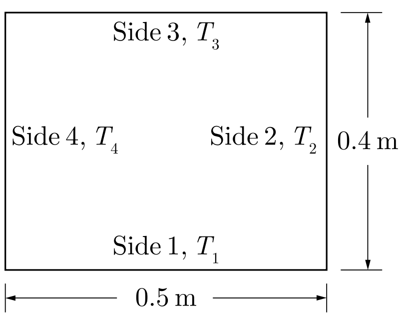
Thermal time constant,

$$t^* = \frac{\rho VC_p}{hA_s} = 16 \text{ sec}$$

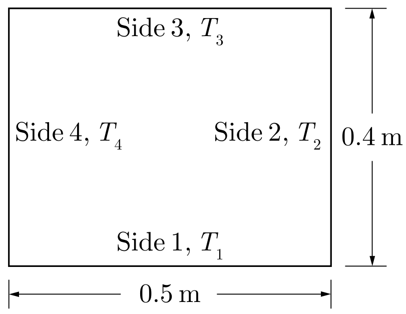
$$\therefore \quad \frac{350 - 300}{1000 - 300} = e^{-1/16} \Rightarrow t = 42.2249 \text{ secs}$$

Q53 An infinitely long furnace of 0.5 m $\times$ 0.4 m cross-section in shown in the figure below. Consider all surfaces of the furnace to be black. The top and bottom walls are maintained at temperature $T_1 = T_3 = 927^\circ$C while the side walls are at temperature $T_2 = T_4 = 527^\circ$C. The view factor, F_{1-2} is 0.26. The net radiation heat loss or gain on side is ______ w/m

Stefan-Boltzmann constant $= 5.67 \times 10^{-8}$ W/m^2 - K^4



S1 Correct answer is 24530.688 W/m



$$T_1 = 927^\circ\text{C} = 1200 \text{ K}$$
$$T_2 = 527^\circ\text{C} = 800 \text{ K}$$
$$F_{12} = F_{14} = 0.26$$
$$F_{11} + F_{12} + F_3 + F_4 = 1$$
$$F_3 = 0.48$$
$$Q = Q_{12} + Q_{13} + Q_{14}$$
$Q_{13} = 0$ sine the temperatures are same
$$Q = Q_{12} + Q_{14} = 2 \times \sigma_b \times A \times F_{12}(T_1^4 - T_2^4)$$
$$Q = Q_{12} + Q_{14} = 2 \times \sigma_b \times A \times F_{12}(T_1^4 - T_2^4)$$
$$Q = 2 \times 5.67 \times 10^{-8} \times (0.5 \times 1) \times 0.26 \times (1200^4 - 800^4) = 24530.688 \text{ watt}$$

Q54 A fluid (Prandtl number, Pr = 1) at 500 K flows over a flat plate of 1.5 m length, maintained at 300 K. The velocity of the fluid id 10 m/s. Assuming kinematic viscosity, $v = 30 \times 10^{-6}$ m^2/s, the thermal boundary layer thickness (in mm) at 0.5 m from the leading edge is ______

S1 Correct answer is 6

$$V = 10 \text{ m/s}$$
$$x = 0.5 \text{ m}$$
$$V = 30 \times 10^{-6} \text{ m}^2/\text{s}$$
$$\text{Re}_x = \frac{V \times x}{u} = \frac{10 \times 0.5}{30 \times 10^{-6}} = 166666.66 = 1.667 \times 10^5 < 5 \times 10^5$$

$\therefore$ Flow is laminar

$$\frac{\delta h}{\delta t} = (\text{Pr})^{1/3} = 1$$
$$\therefore \quad \delta_h \ \delta_t$$
$$\delta_h = \frac{5x}{\sqrt{\text{Re}_x}} = \frac{5 \times 0.5}{\sqrt{1.667 \times 10^5}} = 6.123 \times 10^{-3} \text{ m} = 6.12 \text{ mm}$$

Q55 For water at 25°C, $\frac{dp_s}{dT_s} = 0.189$ kPa/K (p_s is the saturation pressure in kPa and T_s is the saturation temperature in K) and the specific volume of dry saturated vapour is 43.38 m^3/kg. Assume that the specific volume of liquid is negligible in comparison with that of vapour.

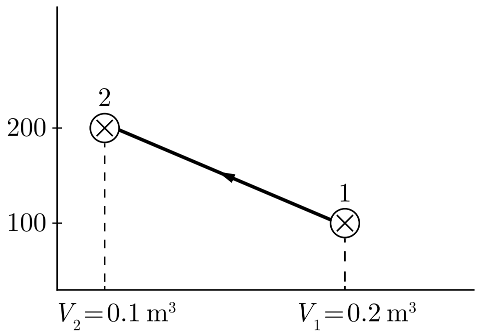
Using the Clausius-Clapeyron equation, an estimate of the enthalpy of evaporation of water at 25°C (in kJ/kg) is ______

S1 Correct answer is 2443.25 kj/kg

$$\begin{aligned}\frac{dp_s}{dT_s} &= 0.189\frac{\text{kPa}}{\text{K}}\\ T_{sat} &= 273+25\\ &= 298\text{ K}\\ V_g &= 43.38\,\text{m}^3/\text{kg}\\ V_f &= 0\\ V_{fg} &= V_g - V_f\\ &= 43.38\,\frac{\text{m}^3}{\text{kg}}\\ \frac{dP}{dT} &= \frac{h_{fg}}{T_{sat}\times V_{fg}}\\ 0.189 &= \frac{h_{fg}}{T_{sat}\times v_{fg}}\\ &= \frac{h_{fg}}{298\times 43.38}\\ h_{fg} &\ 2443.25\text{ kj/kg}\end{aligned}$$

Q56 An ideal gas undergoes a reversible process in which the pressure varies linearly with volume. The conditions at the start (subscript 1) and at the end (subscript 2) of the process with usual notation are: $p_1 = 100$ kPa, $V_1 = 0.2\,\text{m}^3$ and $p_2 = 200$ kPa, $V_2 = 0.1\,\text{m}^3$ and the gas constant, $R = 0.275$ kJ/kg-K. The magnitude of the work required for the process (in kJ) is ______

S1 Correct answer is 15



$$\begin{aligned}W_2 &= \frac{1}{2}(p_1+p_2)(V_1 - V_2)\\ &= \frac{1}{2}(100+200)(0.2-0.1)\\ &= 15\text{ kJ}\end{aligned}$$

Q57 In a steam power plant operating on an ideal Rankine cycle, superheated steam enters the turbine at 3 MPa and 350°C. The condenser pressure is 75 kPa. The thermal efficiency of the cycle is ______ present.

Given data:

For saturated liquid, at $P = 75$ kPa,

$$\begin{aligned}h_f &= 384.39\text{ kJ/kg}\\ v_f &= 0.001037\,\text{m}^3/\text{kg}\\ S_f &= 1.213\text{ kJ/kg-K}\end{aligned}$$

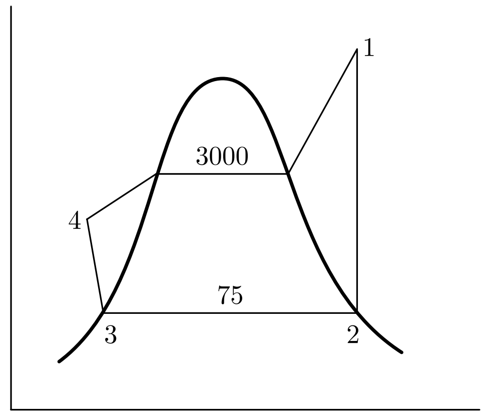
At 75 kPa,

$$\begin{aligned}h_{fg} &= 2278.6\text{ kJ/kg}\\ S_{fg} &= 6.2434\text{ kJ/kg-K}\end{aligned}$$

At $P = 3$ MPa and $T = 350$°C (superheated steam),

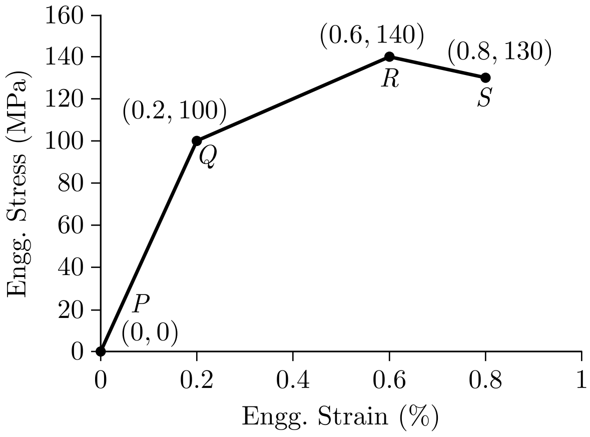
$$\begin{aligned}h &= 3115.3\,\text{kJ/kg}\\ S &= 6.7428\text{ kJ/kg-K}\end{aligned}$$

S1 Correct answer is 6



$$\begin{aligned}h_1 &= 3115.3\text{ kj/kg}\\ S &= 6.7428\text{ kj/kg-K}\\ S_1\ S_2 &= S_f \times S_{fg}\\ 6.7428 &= 1.213 + x\times 6.2434\\ x &= \frac{6.7428-1.213}{6.2434}\\ &= \frac{5.5298}{6.2434}\\ &= 0.8857\\ h_2 &= h_f + xh_{fg}\\ &= 384.39 + 0.8857\times 2278.6\\ &= 384.39 + 0.8857\times 2278.6\\ &= 384.39 + 2018.16\\ &= 2402.55\text{ kj/kg}\\ \text{Pump work} &= W_p\\ &= v_f(p_4 - p_3)\\ &= 3.033\text{ kj/kg}\\ h_4 &= h_3 + v_f\times(p_4-p_3)\\ &= 384.34 + 0.001037(3000-75)\\ &= 384.34 + 3.033\\ &= 387.37\text{ kj/kg}\\ W_{net} &= W_T - W_P\\ &= (h_1 - h_2) - W_P\\ &(3115.3 - 2402.55) - 3.033\\ &= 709.72\ \text{ kj/kg}\\ Q_S &= \text{Heat supplied}\\ &= h_1 - h_4\\ &= 3115.3 - 387.37\\ &= 2727.93\text{ kj/kg}\\ \eta_{th} &= \frac{W_{net}}{Q_S}\\ &= \frac{709.72}{2727.93}\times 100\\ &= 0.26\text{ or }26\%\end{aligned}$$

Q58 A hypothetical engineering stress-strain curve shown in the figure has three straight lines PQ, QR, RS with coordinates $P(0,0)$, $Q(0.2,100)$, $R(0.6,140)$ and $S(0.8,130)$. 'Q' is the yield point, 'R' is the UTS point and 'S' the fracture point.

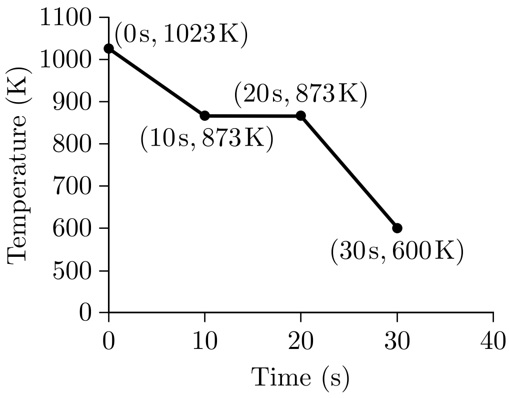


The toughness of the material (in MJ/m^3) is ______

S1 Correct answer is 0.85

$$\text{Toughness} = \text{Area under diagram}$$
$$= \frac{1}{2} \times \frac{0.2}{100} \times 100 + \frac{1}{2}\left(\frac{0.4}{100}\right)(100 + 140)$$
$$+ \frac{1}{2}\left(\frac{0.2}{100}\right)(140 + 130)$$
$$T = 0.1 + 0.48 + 0.27$$
$$= 0.85 \, MJ/m^3$$

Q59 Heat is removed from a molten metal of mass 2 kg at a constant rate of 10 kW till it is completely solidified. The cooling curve is shown in the figure.



S1 Correct answer is 50

$$m = 2 \text{ kg}$$
$$Q = 10 \text{ kW}$$

Time taken for removing latent heat

$$= 20 - 10$$
$$= 10 \text{ sec}$$
$$\text{Time} = \frac{\text{Latent heat}}{Q}$$
$$\text{Latent heat} = \text{time} \times Q$$
$$= 10 \times 10$$
$$= 100 \text{ KJ}$$
$$\text{Latent heat/kg} = \frac{100}{2}$$
$$= 50 \text{ KJ/Kg}$$

Q60 The tool life equation for HSS tool is $VT^{0.14}F^{0.7} d^{0.4} =$ Constant. The tool life (T) of 30 mm is obtained using the following cutting conditions:

$$V = 45 \text{ m/min},$$
$$f = 0.35 \text{ mm}$$
$$d = 2.0 \text{ mm}$$

If speed (V), feed (f_1) and depth of cut (d_1) are increased individually by 25%, the tool life (in min) is

(A) 0.15

(B) 1.06

(C) 22.50

(D) 30.0

S1 Correct option is (B)

$$VT^{0.14}F^{0.7}d^{0.4} = C$$
$$\Rightarrow \quad T_1 = 30 \text{ min}$$
$$V_1 = 45 \text{ m/min}$$
$$f_1 = 0.35 \text{ mm}$$
$$d_1 = 2.0 \text{ mm}$$
$$\Rightarrow \quad c = V_1(T_1)^{0.14}(f_1)^{0.7}(d_1)^{0.4}$$
$$C = 45(30)^{0.14}(0.35)^{0.7}(2)^{0.4}$$
$$C = 45.8425$$
$$V_2(T_2)^{0.14}(f_2)^{0.7}(d_2)^{0.4} = 45.8425$$
$$(125 \times 45) \times (T_2)^{0.14} \times (1.25 \times 0.35)^{0.7} \times (1.25 \times 2)^{0.4}$$
$$= 45.8425$$
$$\Rightarrow \quad T_2 = 1.06 \text{ min}$$

Q61 A cylindrical job with diameter of 200 mm and height of 100 mm is to be cast using modulus method of riser design. Assume that the bottom surface of cylindrical riser does not contribute as cooling surface. If the diameter of the riser is equal to its height, then the height of the riser (in mm) is

(A) 150

(B) 200

(C) 100

(D) 125

S1 Correct option is (A)

According to modulus method

$$M_R = 1.2\, M_C$$
$$\left[\frac{V}{AS}\right]_R = 1.2\left[\frac{V}{AS}\right]_C$$

If diameter or rise = height of riser for top riser D=H

$$\Rightarrow \quad D = 6\, M_C$$
$$D = 6 \times \frac{\frac{\pi}{4} \times (200)^2 \times 100}{2 \times \frac{\pi}{4} \times 200^2 + \pi \times 200 \times 100}$$
$$D = H$$
$$= \frac{6 \times 200 \times 100}{400 + 400}$$
$$= 150 \text{ mm}$$

Q62 A 300 mm thick slab is being cold rolled using roll of 600 mm diameter. If the coefficient of friction is 0.08, the maximum possible reduction (in mm) is ______

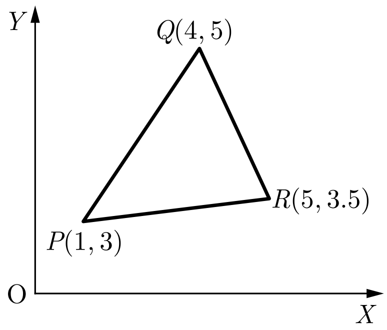
S1 Correct answer is 1.92

Maximum possible reduction

$$\frac{\Delta H}{\text{pass}} = \mu^2 R$$

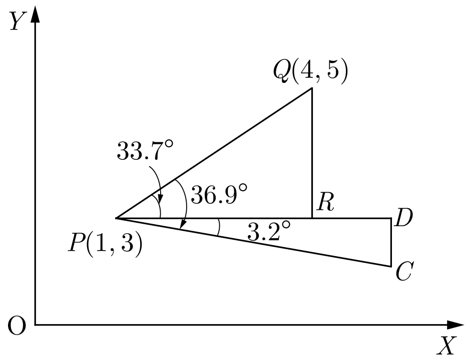
$= 0.08^2 \times 300$
$= 1.92$ mm

Q63 The figure below represents a triangle PQR with initial coordinates of the vertices as $P(1,3)$, $Q(4,5)$ and $R(5,3,5)$. The triangle is rotated in the X - Y plane about the vertex P by angle θ in clockwise direction. If $\sin\theta = 0.6$ and $\cos\theta = 0.8$, the new coordinates of the vertex Q are



(A) (4.6, 2.8)
(B) (3.2, 4.6)
(C) (7.9, 5.5)
(D) (5.5, 7.9)

S1 Correct option is (A)



$$PQ = \sqrt{2^2 + 3^2} = 3.6055 = PC$$
$$PD = PC \times \cos 3.2 = 3.6$$
X co-ordinate of point $C = 1 + 3.6 = 4.6$
$$DC = 3.6 \sin 3.2 = 0.2$$
Y co-ordinate of point, $C = 3.0 - 0.2 = 2.8$

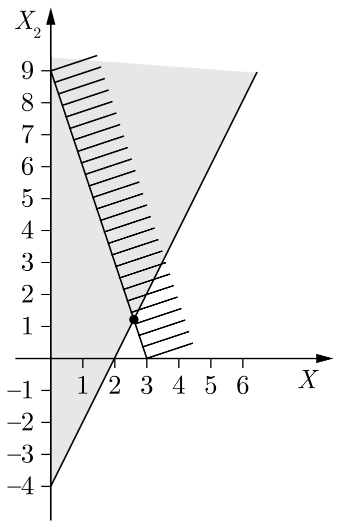
Q64 The annual demand for an item is 10,000 units. The unit cost is Rs. 100 and inventory carrying charges are 14.4% of the unit cost per annum. The cost of one procurement is Rs. 2000. The time between two consecutive orders to meet the above demand is ______ month(s).

S1 Correct answer is 2
Annual demand $(D) = 10000$ units
Unit cost (C_u) Rs. 100
Carrying cost $(C_c) = 14.4\%$ of unit cost
Ordering cost $(c_0) =$ Rs.2000
Cycle time $(T) = ?$

$$T = \frac{1}{N} = \frac{EOQ}{D}$$
$$EOQ = \sqrt{\frac{2QC_0}{C_c}} = \sqrt{\frac{2 \times 10000 \times 2000}{100 \times 0.144}} = 1666.66 \text{ units}$$
$$T = 0.1666 \times 12 = 2 \text{ months}$$

Q65 Maximize $Z = 15X_1 + 20X_2$
Subject to
$12X_1 + 4X_2 \geq 36$
$12X_1 - 6X_2 \leq 24$
$X_1, X_2 \geq 0$
The above linear programming problem has
(A) infeasible solution
(B) unbounded solution
(C) alternative optimum solutions
(D) degenerate solution

S1 Correct option is (B)
Max $Z = 15X_1 + 20X_2$
Subjected to
$12X_1 + 4X_2 \geq 36$
$12X_1 - 6X_2 \leq 24$
$X_1, X_2 \geq 0$
$\therefore$ unbounded solution.



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