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GATE 2016

Detailed Solutions For Mechanical Engineering

Date: 30-01-2016
Forenoon Session

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GENERAL APTITUDE

Q. 1 – Q. 5 carry one mark each

01. 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

01. Ans: (A)

Sol: 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.

02. The policeman asked the victim of a theft, "What did you _____?"

(A) loose (B) lose

(C) loss (D) louse

02. Ans: (B)

Sol: 'lose' is verb

03. Despite the new medicine's ______in treating diabetes, it is not ________ widely

(A) effectiveness----prescribed (B) availability ---- used

(C) prescription----available (D) acceptance ---proscribed

03. Ans: (A)

Sol: 'effectiveness' is noun and 'prescribed' is verb. These words are apt and befitting with the word 'medicine'.

04. 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

04. Ans: (A)

Sol: Total no. of fruits = 5692000

Unripe type of apples = 45% of 15% of 5692000

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

$$= 384210$$

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

$$= 1644988$$

$\therefore$ Total no. of apples = 384210 + 1644988

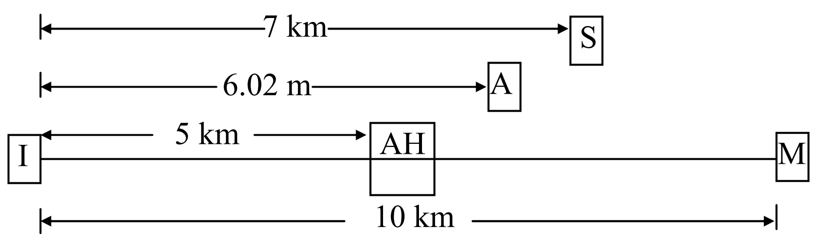
= 2029198

05. Michael lives 10 km away from where I live. Ahmed lives 5 km away and Susan lives 7km 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

05. Ans: (c)

Sol: From given data, the following diagram is possible



I = I live

AH = Ahmed lives

M = Michael lives

S = Susan lives

A= Arun lives

$\rightarrow$ Arun lives farthes away than Ahmed means more than 5 km but closer than Susan means less than 7 km, from given alternatives, option 'C' only possible.

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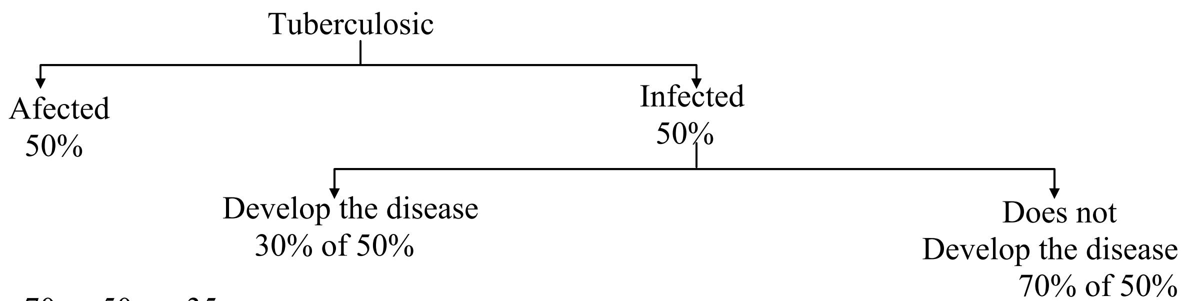
Q. 6 – Q. 10 carry two marks each.

06. 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

06. Ans: (C)

Sol:



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

07. 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 them

(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

07. Ans: (B)

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

08. 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 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

08. Ans: (D)

Sol: From given data, the following arrangement is possible

Shiva

Leela

Pavithra

Among four alternatives, option D is TRUE.

09. 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

09. Ans: (C)

Sol: $q^{-a} = \frac{1}{r} \quad \Rightarrow \frac{1}{q^{a}} = \frac{1}{r} \Rightarrow q^{a} = r$

$r^{-b} = \frac{1}{s} \Rightarrow \frac{1}{r^{b}} = \frac{1}{s} \Rightarrow s = r^{b}$

$s^{-c} = \frac{1}{q} \Rightarrow \frac{1}{s^{c}} = \frac{1}{q} \Rightarrow s^{c} = q$

$q^{a} = r \Rightarrow \left(s^{c}\right)^{a} = r \Rightarrow s^{ac} = r$

$(s^{ac})^{b} = s$

$s^{abc} = s'$

$\therefore$ abc = 1

$\therefore$ Option 'C' is correct.

10. 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 along 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

10. Ans: (C)

Sol: Q can finish the task = 25 days, 12 hrs/day

$$= 300 \text{ hrs, } 1 \text{ hr } = \frac{1}{300}\text{th}$$

R can finish the task = 50 days, 12 hrs/day

$$= 50 \times 12$$

$$= 600 \text{ hrs, } 1\text{hr} = \frac{1}{600}\text{th}$$

Q working hours $\Rightarrow (7 - 2) \times 12 = 60$ hrs

R working hours $\Rightarrow 7 \times 18 = 126$ hrs

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

Q : R

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

20 : 21

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HEARTY CONGRATULATIONS TO OUR IES - 2015 TOPPERS

Total no.of selections in IES 2015 - EC : 52 EE : 36 CE : 24 ME : 28

24 SELECTIONS IN TOP 10

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Q. 1 – Q. 25 carry one mark each:

01. The solution to the system of equations is $\begin{bmatrix} 2 & 5 \\ -4 & 3 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{Bmatrix} 2 \\ -30 \end{Bmatrix}$

(A) 6,2 (B) – 6,2 (C) – 6, –2 (D) 6, –2

01. Ans: (D)

Sol: x = 6, y = –2 is the solution of equation

2x+5y = 2 and –4x + 3y = –30

02. 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) $\int_0^\infty e^{-ist} f(t) dt$

02. Ans: (B)

Sol: By the definition of Laplace transform of f(t) $\forall t \geq 0$, we have

$$F(s) = L\{f(t)\} = \int_0^\infty e^{-st} f(t) dt$$

03. f(z) = u(x,y) + i v(x,y) is an analytic function of complex variable z = x + iy where $i = \sqrt{-1}$. If u(x,y) = 2 xy, 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

03. Ans: (A)

Sol: 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

04. 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) $\sqrt{\mu}$ (B) μ^2 (C) μ (D) 1/μ

04. Ans: (A)

Sol: For Poisson distribution mean = variance

given mean = μ

$\therefore$ variance = μ

$\therefore$ standard deviation = $\sqrt{\mu}$

05. 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 __________.

05. Ans: (1.564)

Sol: Let $f(x) = x - 10\cos(x)$ & $x_0 = \left(\frac{\pi}{4}\right)$

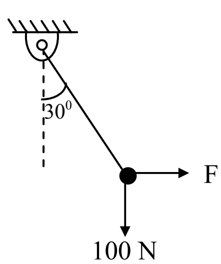
Then $f'(x) = 1 + 10\sin(x)$

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)} = \frac{\pi}{4} - \frac{\left(\frac{\pi}{4} - \frac{10}{\sqrt{2}}\right)}{\left(1 + \frac{10}{\sqrt{2}}\right)}$$

$$\Rightarrow \frac{\pi}{4} + \frac{(6.2857)}{(8.0711)}$$

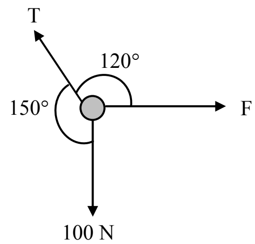
$\therefore x_1 = 1.5641$

06. 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 _____



06. Ans: (57.735)

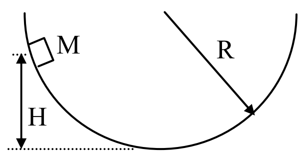
Sol:



By Lami's' theorem

$$\frac{F}{\sin 150^0} = \frac{100}{\sin 120^0} \Rightarrow F = 57.735\text{ N}$$

07. A point mass M is released from rest and slides down a spherical bowl (of 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

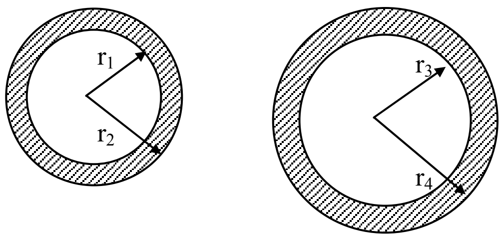
07. Ans: (C)

Sol: By Energy Conservation

$$mgH = \frac{1}{2}mv^2$$

$$\Rightarrow V = \sqrt{2gH}$$

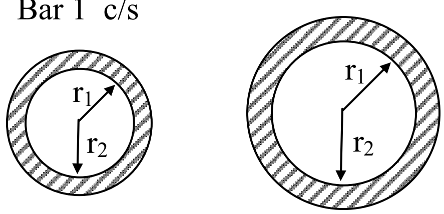
08. The cross sections of two hollow bars made of the same material are concentric circles as shown in the figure. It is given that $r_3 > r_1$ and $r_4 > r_2$, and that the areas of the cross-sections are the same. J_1 and J_2 are the torsional rigidities of the bars on the left and right, respectively.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



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

08. Ans: (A)

Sol:



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

$A_1 = A_2$

$$\Rightarrow \pi\left[r_2^2 - r_1^2\right] = \pi\left[r_4^2 - r_3^2\right]$$

$$\therefore\ r_2^2 - r_1^2 = r_4^2 - r_3^2 \Rightarrow r_3^2 - r_1^2 = r_4^2 - r_2^2$$

$$\therefore\ \frac{J_2}{J_1} = \frac{\frac{\pi}{2}\left[r_4^4 - r_3^4\right]}{\frac{\pi}{2}\left[r_2^4 - r_1^4\right]} = \frac{\left(r_4^2 + r_3^2\right)\left(r_4^2 - r_3^2\right)}{\left(r_2^2 + r_1^2\right)\left(r_2^2 - r_1^2\right)}$$

$$= \frac{r_4^2 + r_3^2}{r_2^2 + r_1^2} \qquad \left[\because r_4^2 - r_3^2 = r_2^2 - r_1^2\right]$$

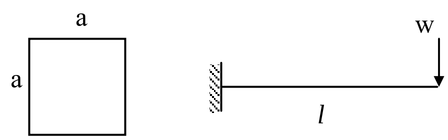
$$\frac{J_2}{J_1} > 1 \qquad \left[\because r_4 > r_2\ \&\ r_3 > r_1\right]$$

09. 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 decreases approximately by

(A) 19% (B) 29% (C) 41% (D) 50%

09. Ans: (D)

Sol:



$$\delta_1 = \frac{W\ell^3}{3EI}$$

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

$\delta_2 = 0.5(\delta_1)$

δ_2 reduced by 50%

10. 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_____

10. Ans: (200)

Sol: R=100m, v = 20m/sec $\omega_p = \frac{V}{R} = 0.2\frac{\text{rad}}{\text{sec}}$

$\omega_s = 100\text{rad/sec}$

I = 10kg-m^2

Gyroscopic moment = $I\omega_s\omega_p$

$= 10\times0.2\times100$N-m

= 200N-m

11. 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

11. Ans: (20)

Sol: $k = 10 kN / m$

$F_0 = 100$ N

$\xi = 0.25$

$$X = \frac{(F_0 / k)}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2 + \left(2\zeta\frac{\omega}{\omega_n}\right)^2}}$$

$\frac{\omega}{\omega_n} = 1$ at resonance

$$X = \frac{F_0}{2k\zeta} = \frac{100}{2\times10\times0.25\times10^3} = 20 \text{ mm}$$

12. 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

12. Ans: (B)

13. The instantaneous stream-wise velocity of a turbulent flow is given as follows:

$u(x,y,z,t) = \bar{u}(x,y,z) + \mu'(x,y,z,t)$

The time –average of the fluctuating velocity $u'(x,y,z,t)$

(A) $u'/2$ (B) $-\frac{\bar{u}}{2}$ (C) zero (D) $\frac{\bar{u}}{2}$

13. Ans: (C)

Sol: Time average of fluctuating velocity is zero.

14. 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

14. Ans: (D)

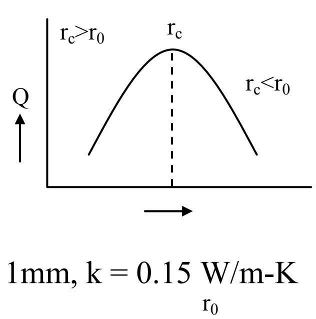
Sol: For floating body Buoyancy force acts through the centre of buoyancy which is C.G for displaced volume.

15. A plastic sleeve of outer radius r_o = 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

15. Ans: (A)

Sol:



r_0 = 1mm, k = 0.15 W/m-K

$h = 25 W/m^2\text{–}K$

$r_c = \dfrac{k}{h_0}$ for cylindrical shape

$= \dfrac{0.15}{25} \times 1000 = 0.15 \times 40 = 6mm$

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

16. 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)

16. Ans: (B)

17. 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 ____

17. Ans: (14.29%)

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

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:

$2a + b + c = 0.9 \times 5 \times 2 = 9$

$2a + b + c = 9$

$\Rightarrow 2a + b + 4 = 9 \Rightarrow 2a + b = 5 \ldots (1)$

$a + b = 3 \qquad \ldots (2)$

By solving (1) & (2)

$a = 2$ & $b = 1$

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

$$= \frac{b}{a+b+c} \times 100$$

$$= \frac{1}{2+1+4} \times 100$$

$$= \frac{1}{7} \times 100 = 14.29\%$$

18. Consider two hydraulic turbines 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 _________.

18. Ans: (0.25)

Sol: $N_S = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$

Given $N_{S_1} = N_{S_2}$, $H_1 = H_2$,

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

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

19. The INCORRECT statement about regeneration in vapor power cycle is that

(A) it increases 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

19. Ans: (C)

20. The "Jominy test" is used to find

(A) Young's modulus (B) hardenability

(C) yield strength (D) thermal conductivity

20. Ans: (B)

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

21. Under optimal conditons of the process the temperatures experienced by a copper work piece in fusion 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) $T_{welding} > T_{brazing} > T_{soldering}$

21. Ans: (D)

Sol: 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 427^0C and soldering is below 427^0C

22. 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

22. Ans: (C)

Sol: 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.

23. 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

23. Ans: (A)

Sol: Electron beam machining is the only method carried out under vacuum, to avoid the dispersion of electrons after the magnetic deflector.

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

24. Ans: (0.5)

Sol: Because the rake angle is zero, F= Friction force = F_c = Cutting force = 500N, N = Normal to friction force = F_t = Thrust force = 250N,

Coefficient of friction = F/N = 250 / 500 = 0.5

25. 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

Codes:

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

25. Ans: (A)

Sol 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.26 to 55 (Two marks Questions)

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

26. Ans: (–5)

Sol: $f(x) = 2x^3 - 3x^2$ 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

Global minimum = −5

27. If y = f(x) satisfies the boundary value problem $y'' + 9y = 0$, $y(0) = 0$, $y\left(\frac{\pi}{2}\right) = \sqrt{2}$,then $y\left(\frac{\pi}{4}\right)$ is ________.

27. Ans: (–1)

Sol: $y'' + 9y = 0$

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

$m = \pm 3i$

$y = y_c + y_p$

$y = C_1 \cos 3x + C_2 \sin 3x$ -------(1)

$(\because y_p = 0)$

If x = 0 , y = 0

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

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

(2) $\sqrt{2} = C_1(0) + C_2 \sin(3\pi/2)$

$= C_2(-1)$

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

If $x = \pi/4$

$y(\pi/4) = -\sqrt{2} \sin (3\pi/4)$

$= -\sqrt{2}\left(\frac{1}{\sqrt{2}}\right) = -1$

28. 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) $-\pi \sin\frac{(1)}{e}$ (B) $-\pi \cos\frac{(1)}{e}$ (C) $\sin\frac{(1)}{e}$ (D) $\cos\frac{(1)}{e}$

28. Ans: (A)

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

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

Then poles of f(z) are given by $z^2 + 2z + 2 = 0$

$\therefore z = -1 \pm i$

$R_1 = \text{Res}(f(z): z = -1 + i) = \underset{z\to -1+i}{\text{Lt}} [z-(-1+i)] \frac{e^{iz}}{[z-(-1+i)][z-(-1-i)]}$

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

$\int_c f(z)dz = \int_c \frac{I_m(e^{iz})}{z^2+2z+2} dz = I_m[2\pi i(R_1)]$

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

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

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

29. Gauss-Seidel method is used to solve the following equations (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 ________

29. Ans: (– 6)

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

$2x + 3y + z = 1$

$3x + 2y + z = 3$ and $x_0 = 0$, $y_0 = 0$, $z_0 = 0$

Then first iteration will be

$x_1 = x_1 = 5 - 2y_0 - 3z_0 = 5 - 0 - 0 = 5$

$x_2 = y_1 = \frac{1}{3}(1 - 2x_1 - z_0) = \frac{1}{3}(1 - 10 - 0) = -3$

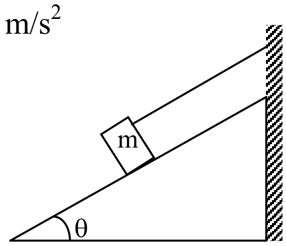
$x_3 = z_1 = 3 - 3x_1 - 2y_1 = 3 - 15 + 6 = -6$

$\therefore x_3 = -6$

30 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.

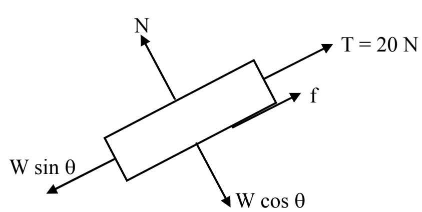
Take $\cos\theta = 0.8$ and $\sin\theta = 0.6$.

Acceleraiton due to gravity $g = 10$ m/s^2



30. Ans: (5)

Sol:



$\sum F_Y = 0$

$\Rightarrow N = W \cos\theta$

$= 0.8\ W$

$f = \mu N$

$= 0.2\ W$

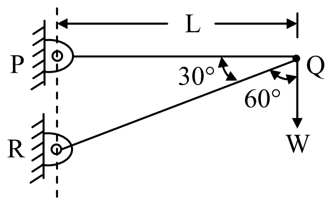
$\sum F_x = 0$

$\Rightarrow 0.6\ W = 20 + 0.2\ W$

$\Rightarrow W = 50\ N$

$\Rightarrow m = 5\ kg$

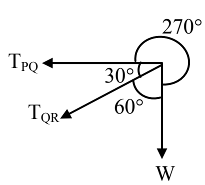
31. A two –member truss PQR is supporting a load W. The axial forces in members PQ and QR are respectively



(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

31. Ans: (B)

Sol:



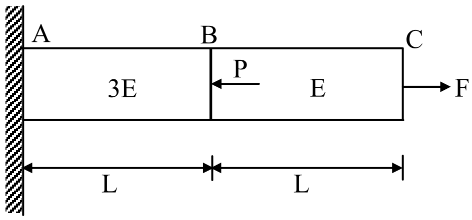
By Lami's theorem

$$\frac{W}{\sin 30} = \frac{T_{PQ}}{\sin 60} = \frac{T_{QR}}{\sin 270}$$

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

$\Rightarrow T_{QR} = -2\ W = 2\ W(C)$

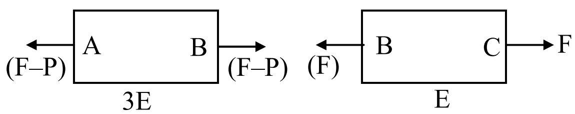
32. A horizontal bar with a constant cross-section is subjected to loading as shown in the figure. The Young's moduli for the sections AB and BC are 3E and E, respectively.



For the deflection at C to be zero, the ratio P/F is ____

32. Ans: (4)

Sol:



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

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

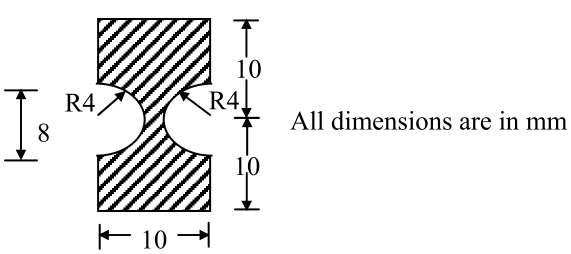
$$\frac{(F-P)}{3} + F = 0$$

$F - P + 3F = 0$

$4F = P$

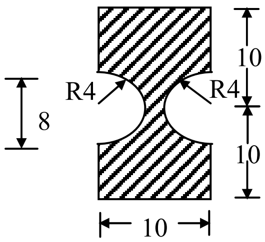
$$\frac{P}{F} = 4$$

33. 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 ________



33. Ans: (21439.07)

Sol:

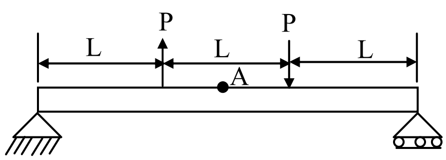


$$I = \frac{10\times 20^3}{12} + 10\times 20(10)^2 - \left[\frac{\pi}{64}\times(8^4) + \frac{\pi}{4}\times(8^2)(10)^2\right]$$

$= 26666.67 - 5227.6$

$= 21439.07\ mm^4$

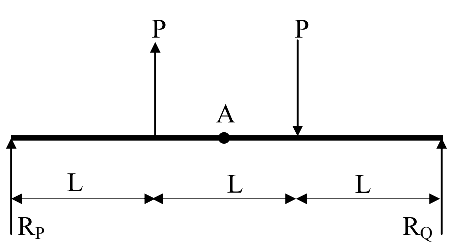
34. A simply-supported beam of length 3L is subjected to the loading shown in the figure.



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 100 mm. The bending stress (in Pa) at the point A located at the top surface of the beam at a distance of 1.5L from the left end is (Indicate compressive stress by a negative sign and tensile stress by a positive sign).

34. Ans: (Zero)

Sol:



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

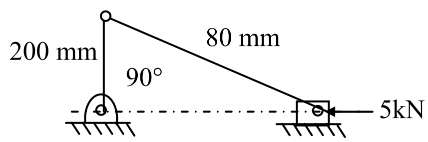
$R_Q(3L) = P(L)$

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

$M_A = R_Q(1.5L) - P(0.5L) \Rightarrow \frac{P}{3}(\frac{3}{2}L) - \frac{P}{2}L$

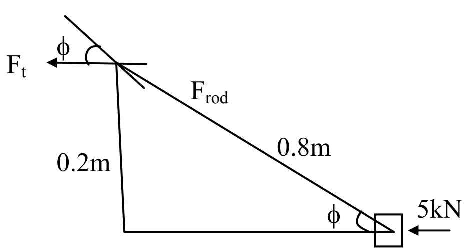
$M_A = 0 \Rightarrow \sigma_A = 0 [\because \sigma \propto M]$

35. 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 counterclockwise 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



35. Ans: (1)

Sol:



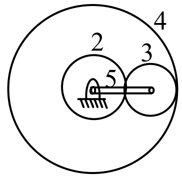
Given $F_p = 5kN$

$F_{rod} = \frac{F_p}{\cos\phi}, F_t = F_{rod}\cos\phi$

$\therefore F_t = 5kN$

Turning moment = $F_t.r = 5 \times 0.2 = 1kN\text{-}m$

36. 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

36. Ans: (C)

Sol: Given $T_2 = 60$ $N_2 = 0$ $T_3 = 20$

$T_4 = 100$ $N_4 = 100\text{rpm}$ (ccw +ve)

Relative velocity equation

$$\frac{N_4 - N_a}{N_2 - N_a} = -\frac{T_2}{T_4}$$

$$= \frac{100 - N_a}{0 - N_a}$$

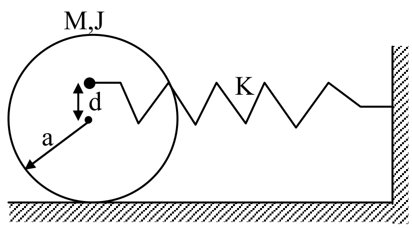
$$= \frac{-60}{100}$$

1.6 Na = 100

$$N_a = \frac{100}{1.6}$$

= 62.5 rpm (ccw)

37. A solid disc with radius a is connected to a spring at a point d above 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 centere is $J = \frac{Ma^2}{2}$



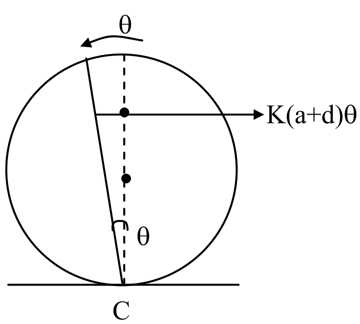
The natural frequency of this system in rad/s is given by

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

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

37. Ans: (A)

Sol: Moment equilibrium above instantaneous centre (contact point) $-k(a+d)\theta.(a+d) = I_c\ddot{\theta}$



$$I_c = \frac{3}{2}ma^2, \omega_n = \sqrt{\frac{k(a+d)^2}{\frac{3}{2}ma^2}}$$

$$\omega_n = \sqrt{\frac{2k(a+d)^2}{3ma^2}}$$

38. The principal stresses at a point inside a solid object are σ_1 = 100 MPa, σ_2 = 100 MPa and σ_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) $n_T = \left(\sqrt{3}\right) n_v$ (C) $n_T = n_v$ (D) $n_v = \left(\sqrt{3}\right)n_T$

38. Ans: (C)

Sol: According to maximum shear stress theory

$$\sigma_1 - \sigma_2 = \frac{S_{yt}}{n_T} \Rightarrow n_T = \frac{200}{100} = 2$$

According to Distortion Energy Theory:

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

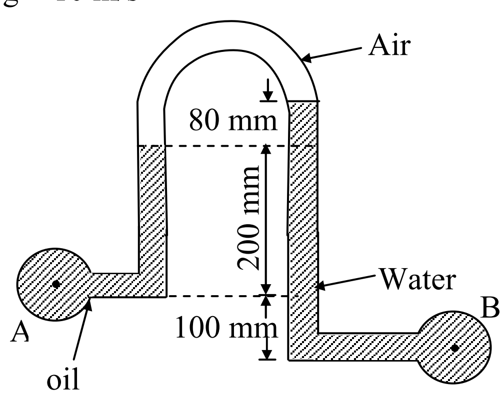
But $\sigma_1 = \sigma_2$, let it is σ_1

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

$\therefore n_T = n_V$

39. 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 are1.16 kg/m and 1000 kg/m^3, respectively. The pressure difference between pipes A and B is _______kPa.

Acceleration due to gravity g = 10 m/s^2



39. Ans: (–2.2)

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

$P_A - P_B = -2.2$ kPa

40. Oil (kinematic viscosity, $\nu_{oil} = 1.0 \times 10^{-5}$ m^2/s) flows through a pipe of 0.5 m diameter with velocity of 10 m/s. Water (Kinematic viscosity, $\nu_w = 0.89 \times 10^{-6}$ m^2/s) is flowing through a model pipe of diameter 20 mm. For satisfying the dynamic similarity, the velocity of water (in m/s) is ____

40. Ans: (22.25)

Sol: **oil** **water**

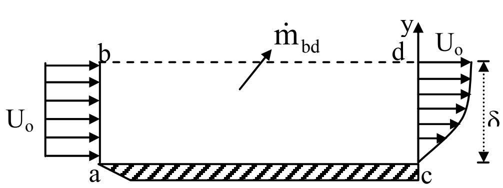
oil	water
$\nu = 1.0 \times 10^{-5}$ m^2/s	$\nu = 0.89 \times 10^{-6}$ m^2/s
d = 0.5 m	d = 0.02 m
v = 10 m/sec	v = ?

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

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

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

41. 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_o . The velocity profile at the inlet a-b is uniform, while that at a downstream location c-d is given by $u = U_o\left[2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2\right]$



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

41. Ans: (0.33)

Sol: mass entering = mass leaving

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

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

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

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

$$\int_0^{\delta} u\,dy = \frac{2}{3} u_0 \rho \delta \text{ …….. (2)}$$

Substitute (2) in 1

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

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

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

42. 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 16s. The time required (in s) to reach the final temperature is________

42. Ans: (42.22 sec)

Sol: Biot Number = $\frac{hL_C}{K}$

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

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

Hence lumped heat analysis is used.

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

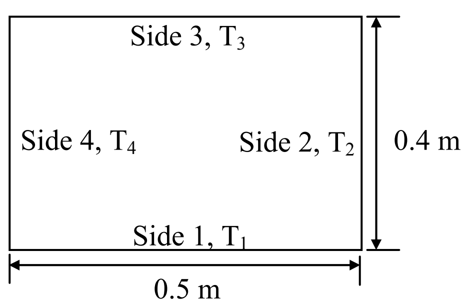
Thermal time constant,

$$t^* = \frac{\rho V C_p}{hA_s} = 16\,sec$$

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

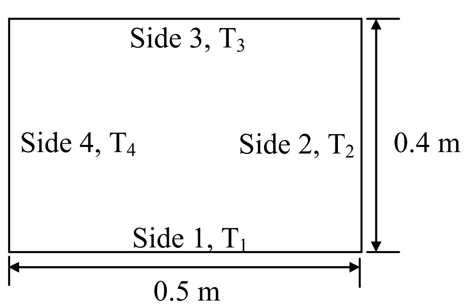
43. An infinitely long furnace of 0.5 m $\times$ 0.4 m cross –seciton is shown in the figure below. Consider all surfaces of the furnace to be black. The top and bottom walls are maintained at temperature $T_1 = T_3 = 927$ °C while the side walls are at temperature $T_2 = T_4 = 527$°C. The view factor,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

Stefan-Boltzman constant = 5.67×10^{-8} W/m^2-K^4



43. Ans: (24530.688 W/m)

Sol:



$T_1 = 927°C = 1200K$,

$T_2 = 527°C = 800K$

$F_{12} = F_{14} = 0.26$

$F_{11} + F_{12} + F_{13} + F_{14} = 1$

$F_{13} = 0.48$

$Q = Q_{12} + Q_{13} + Q_{14}$

$Q_{13} = 0$ since the temperatures are same

$Q = Q_{12} + Q_{14} = 2\times\sigma_b\times A\times F_{12}(T_1^4 - T_2^4)$

$Q = 2\times5.67\times10^{-8}\times(0.5\times1)\times0.26\times(1200^4-800^4)$

$= 24530.688$ Watt

44. 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 is 10 m/s. Asuming kinematic viscosity, $v = 30 \times 10^{-6}$ m²/s, the thermal boundary layer thickness (in mm) at 0.5 m from the leading edge is ____

44. Ans: (6)

Sol: V = 10 m/s, x = 0.5m,

$v = 30\times10^{-6}$ m²/s

$$Re_x = \frac{V\times x}{\upsilon} = \frac{10\times0.5}{30\times10^{-6}}$$

$= 166666.66 = 1.667\times10^5 < 5\times10^5$

∴ Flow is laminar

$$\frac{\delta_h}{\delta_t} = (Pr)^{\frac{1}{3}} = 1$$

$\therefore \delta_h = \delta_t$

$$\delta_h = \frac{5x}{\sqrt{Re_x}}$$

$$= \frac{5\times0.5}{\sqrt{1.667\times10^5}}$$

$= 6.123\times10^{-3}$ m $= 6.12$ mm

45. For water at 25°C, 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 comparson 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 ___

45. Ans: (2443.25kJ/kg)

Sol: $\frac{dP_s}{dT_s} = 0.189 \frac{kPa}{K}$

$T_{sat} = 273 + 25 = 298$ K

$v_g = 43.38$ m^3/kg

$v_f = 0$

$v_{fg} = v_g - v_f$

$= 43.38 - 0$

$= 43.38 \frac{m^3}{kg}$

$$\frac{dP}{dT} = \frac{h_{fg}}{T_{sat} \times V_{fg}}$$

$$0.189 = \frac{h_{fg}}{T_{sat} \times v_{fg}}$$

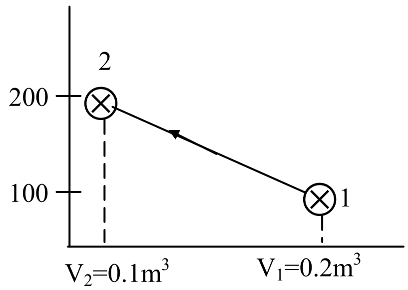
$$= \frac{h_{fg}}{298 \times 43.38}$$

$h_{fg} = 2443.25$ kJ/kg

46. 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 $m^3$and p_2 = 200 kPa, V_2 = 0.1 m^3 and the gas constant, R = 0.275 kJ/kg- K. The magnitude of the work required for the process (in kJ) is______

46. Ans: (15)

Sol:



$$_{1}W_{2} = \frac{1}{2}(P_1 + P_2)(V_2 - V_2)$$

$$= \frac{1}{2}(100 + 200)(0.2 - 0.1) = 15\text{ kJ}$$

47. 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 _______percent.

Given data:

For saturated liquid, at P = 75 kPa,

h_f = 384.39 kJ/kg, v_f = 0.001037 m^3/kg,

s_f = 1.213 kJ/kg-K

At 75 kPa, h_{fg} = 2278.6 kJ/kg,

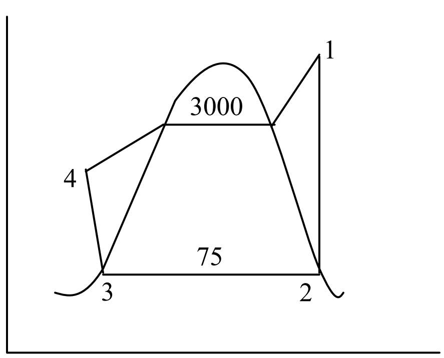
s_{fg} = 6.2434 kJ/kg-K

At P = 3 MPa and T = 350° C (Superheated steam), h = 3115.3 kJ/kg,

s = 6.7428 kJ/kg-K

47. Ans: (26)

Sol:



$h_1 = 3115.3$ kJ/kg

$s_1 = 6.7428$ kJ/kg-K

$s_1 = s_2 = s_f \times s_{fg}$

$6.7428 = 1.213 + x \times 6.2434$

$$x = \frac{6.7428 - 1.213}{6.2434} = \frac{5.5298}{6.2434}$$

$= 0.8857$

$h_2 = h_f + x\, h_{fg}$

$= 384.39 + 0.8857 \times 2278.6$

$= 384.39 + 2018.16 = 2402.55$ kJ/kg

Pump work = $W_P = v_f(p_4 - p_3) = 3.033$ kJ/kg

$h_4 = h_3 + v_f \times (p_4 - p_3)$

$= 384.34 + 0.001037\,(3000 - 75)$

$= 384.34 + 3.033 = 387.37$ kJ/kg

$W_{net} = W_T - W_P$

$= (h_1 - h_2) - W_P$

$= (3115.3 - 2402.55) - 3.033$

$= 709.72$ kJ/kg

Q_S = HEAT SUPPLIED = $h_1 - h_4$

$= 3115.3 - 387.37$

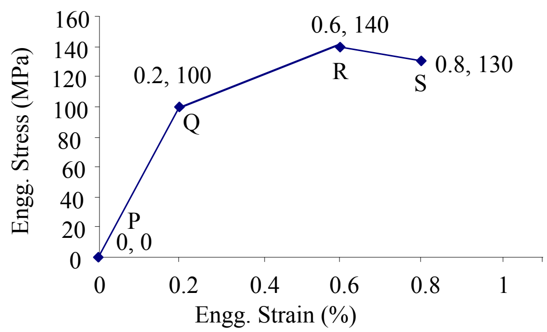
$= 2727.93$ kJ/kg

$$\eta_{th} = \frac{W_{net}}{Q_s}$$

$$= \frac{709.72}{2727.93} \times 100$$

$= 0.26$ or 26%

48. 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 ____

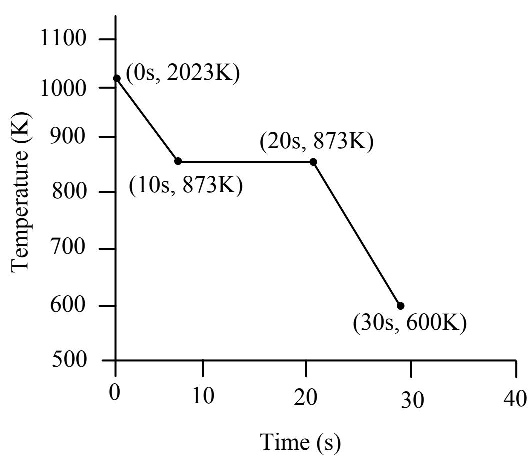
48. Ans: (85)

Sol: Toughness = Area under diagram

$$=\frac{1}{2}\times 0.2\times 100+\frac{1}{2}(0.4)(100+140)+\frac{1}{2}(0.2)(140+130)$$

T = 10 + 48 + 27 = 85 MJ/m^3

49. 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.



Assuming uniform temperature throughout the volume of the metal during solidification, the latent heat of fusion of the metal (in kJ/kg) is ____

49. Ans: (50)

Sol: m = 2 kg, Q = 10 kW

time taken for removing latent heat = 20 – 10 = 10 sec

$$\text{Time} = \frac{\text{Latent heat}}{Q}$$

Latent heat = time × Q

= 10 × 10 = 100 kJ

$$\text{Latent heat/kg} = \frac{100}{2} = 50 \text{ kJ/kg}$$

50. The too life equation for HSS tool is $VT^{0.14}f^{0.7}d^{0.4}$ = Constant. The tool life (T) of 30 min is obtained using the following cutting conditions = 45 m/min, f = 0.35 mm, d = 2.0 mm. If speed (V), feed (f) and depth of cut (D) are increased individually by 25%, the tool life (in min) is

(A) 0.15 (B) 1.06 (C) 22.50 (D) 30.0

50. Ans: (B)

Sol: $VT^{0.14} f^{0.7} d^{0.4} = C$

$\Rightarrow T_1 = 30$ min, $V_1 = 45$ m/min,

$f_1 = 0.35$ mm, $d_1 = 2.0$ mm

$\Rightarrow C = V_1(T_1)^{0.14}(f_1)^{0.7}(d_1)^{0.4}$

$C = 45(30)^{0.14}(0.35)^{0.7}(2)^{0.4}$

$C = 45.8425$

$V_2(T_2)^{0.14}(f_2)^{0.7}(d_2)^{0.4} = 45.8425$

$(125\times45)\times(T_2)^{0.14}\times(1.25\times0.35)^{0.7}\times(1.25\times2)^{0.4} = 45.8425$

$\Rightarrow T_2 = 1.06$ min

51. 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

51. Ans: (A)

Sol: 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 of riser = height of riser for top riser D = H

$\Rightarrow D = 6\ M_c$

$$D = 6\times\frac{\frac{\pi}{4}\times(200)^2\times100}{2\times\frac{\pi}{4}\times200^2+\pi\times200\times100}$$

$$D = H = \frac{6\times200\times100}{400+400} = 150\text{mm}$$

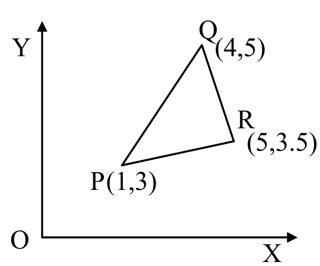
52. A 300 mm thick slab is being cold rolled using roll of 600 mm diameter. If the coefficient of friction is 0.08, the maximum possible reduction (in mm) is ______

52. Ans: (1.92)

Sol: Maximum possible reduction =

$\Delta H/\text{ pass} = \mu^2 R = 0.08^2 \times 300 = 1.92$ mm

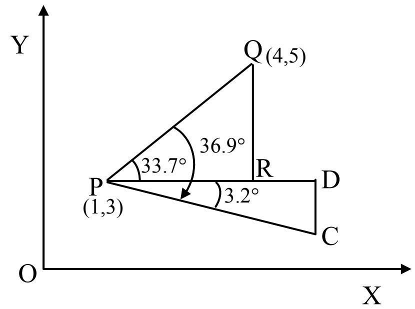
53. The figure below represents a triangle PQR with initial coordinates of the vertices as P(1,3), Q (4,5) and R(5,3.5). The triangle is rotated in the X-Y plane about the vertex P by angle θ in clockwise direction. If sin θ = 0.6 and cos θ = 0.8, the new coordinates of the vertex Q are



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

53. Ans: (A)

Sol:



$$PQ = \sqrt{2^2 + 3^2} = 3.6055 = PC$$

PD = PC × 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

54. 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)

54. Ans: (2)

Sol: 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 = 0.1666×12 = 2 months

55. 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

55. Ans: (B)

Sol: 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.