Mechanical Engineering

General Aptitude

ONE MARK QUESTIONS (Q.01 – Q.05)

01. The cost of 7 pens, 8 pencils and 3 sharpeners is Rs 20. The cost of 3 pencils, 4 sharpeners and 5 erasers is Rs 21. The cost of 4 pens, 4 sharpeners and 6 erasers is Rs 25. The cost of 1 pen, 1 pencil, 1 sharpener and 1 eraser is ________ (Rs)

01. Ans: 6

Sol: Let the costs of pens, pencil, eraser and sharpener be p_n, p_p, e and s respectively

Given

$7p_n + 8p_p + 3s = 20$

$3p_p + 4s + 5e = 21$

$4p_n + 4s + 6e = 25$

Adding all three equations

$11p_n + 11p_p + 11s + 11e = 66$

$\therefore\ 1p_n + 1\,p_p + 1s + 1e = 6$

02. **Sentence Completion:**

Although some think the terms "bug" and "insect" are -------, the former term actually refers to ------- group of insects.

(A) parallel - an identical

(B) precise - an exact

(C) interchangeable - particular

(D) exclusive - a separate.

02. Ans: (C)

Sol: The word "although" indicates that the two parts of the sentence contrast with each other: although most people think about the terms "bug" and "insect" one way, something else is actually true about the terms. Choice (C) logically completes the sentence, indicating that while most people think the terms are "interchangeable," the term "bug" actually refers to a "particular" group of insects.

03. **Sentence improvement:**

<u>Underestimating its value, breakfast is a meal many people skip.</u>

(A) Underestimating its value, breakfast is a meal many people skip

(B) Breakfast is skipped by many people because of their underestimating its value

(C) Many people, underestimating the value of breakfast, and skipping it.

(D) Many people skip breakfast because they underestimate its value.

03. Ans: (D)

Sol: The problem with this sentence is that the opening phrase "underestimating its value" modifies "breakfast," not "people." The order of the words in the sentence in choice (D) does not have this problem of a misplaced modifying phrase. Choice (D) also clarifies the causal relationship between the two clauses in the sentence. None of the other choices convey the information presented in the sentence as effectively and directly as choice (D).

04. **Spot the error, if any:**

If I were her / I would accept / his offer

(A) If I were her,

(B) I would accept

(C) his offer

(D) No error

04. Ans: (A)

Sol: Rule we should use Subjective case of pronoun after BE forms…am, is, are was were.,, has been, have been, had been.

Her is an objective case ---

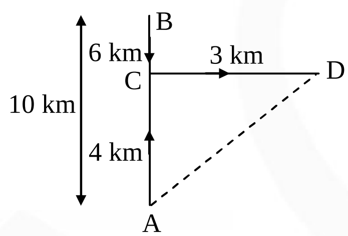
If I were she. is correct

05. Kishenkant walks 10 kilometres towards North. From there, he walks 6 kilometres towards south. Then, he walks 3 kilometres towards east. How far and in which direction is he with reference to his starting point?

(A) 5 kilometres, West Direction
(B) 5 kilometres, North-East Direction
(C) 7 kilometres, East Direction
(D) 7 kilometres, West Direction

05. Ans: (B)

Sol: The movements of Kishenkant are as shown in figure



A to B, B to C and C to D

AC = (AB – BC) = (10 – 6) km = 4 km

Clearly, D is to the North-East of A

∴ Kishenkant's distance from starting point A

$AD = \sqrt{AC^2 + CD^2}$

$= \sqrt{(4)^2 + (3)^2} = \sqrt{25} = 5$ km

So, Kishenkant is 5 km to the North-East of his starting point

TWO MARK QUESTIONS (Q.06 – Q.10)

06. The infinite sum $1 + \frac{4}{7} + \frac{9}{7^2} + \frac{16}{7^3} + \frac{25}{7^4} + - - - - -$ equals

06. Ans: 1.8 to 2

Sol: We have to find the sum of the series

$$1 + \frac{4}{7} + \frac{9}{7^2} + \frac{16}{7^3} + \frac{25}{7^4} + - - - - -$$

Putting $x = \frac{1}{7}$ we get

$1 + 2^2x + 3^2x^2 + 4^2x^3 + 5^2x^4 + - - - - -$

$s = 1 + 4x + 9x^2 + 16x^3 + 25x^4$

$s.x = x + 4x^2 + 9x^3 + 16x^4 + - - - - -$

$s – sx = 1 + 3x + 5x^2 + 7x^3 + 9x^4 + - - - - - -$

$x(s – sx) = x + 3x^2 + 5x^3 + 7x^4 + - - - - - -$

$(s – sx) –x(s – sx) = 1 + 2x + 2x^2 + 2x^3 + - - - - - - +$ to ∞

$(1 – x)^2 s = 1 + \frac{2x}{1-x}$; since $|x| < 1$

$s = \frac{1+x}{(1-x)^3}$

We may use it as direct formula for solving this type of problem

Substituting $x = \frac{1}{7}$ we get

$$s = \frac{1+\frac{1}{7}}{\left(1-\frac{1}{7}\right)^3} = \frac{8 \times 343}{7 \times 216} = \frac{49}{27}$$

07. If $\frac{x}{3a+2b} = \frac{y}{3b+2c} = \frac{z}{3c+2a} = 5$ and a, b and c are in continued proportion and b, c, a are in continued proportion, then $\frac{x}{a} + \frac{y}{2b} + \frac{z}{3c}$ is _______ (∵ a, b and c are in continued proportion means $b^2 = ac$)

(A) $55\frac{1}{5}$ (B) 25

(C) $4\frac{1}{6}$ (D) $45\frac{5}{6}$

07. Ans: (D)

Sol: Given that a, b, c are in continued proportion

$\Rightarrow b^2 = ac$ -------- (1)

Also b, c, a are in continued proportion

$\Rightarrow c^2 = ab$ ------- (2)

From (1) and (2)

$b^2c^2 = a^2bc \Rightarrow a^2 = bc$ ------- (3)

Conditions (1), (2) and (3) can only be satisfied when a = b = c = k (say)

$$\therefore \frac{x}{5k}=\frac{y}{5k}=\frac{z}{5k}=5 \Rightarrow \frac{x}{k}=\frac{y}{k}=\frac{z}{k}=25$$

$$\therefore \frac{x}{a}+\frac{y}{2b}+\frac{z}{3c}=\frac{x}{k}+\frac{1}{2}\frac{y}{k}+\frac{1}{3}\frac{z}{k}$$

$$=25+\frac{25}{2}+\frac{25}{3}$$

$$=\frac{25\times 11}{6}=\frac{275}{6}=45\frac{5}{6}$$

08. Rasputin was born in 3233 B.C. The year of birth of Nicholas when successively divided by 25, 21 and 23 leaves remainder of 2, 3 and 6 respectively. If the ages of Nicholas, Vladimir and Rasputin are in arithmetic progression, when was Vladimir born?

(A) 3227 B.C (B) 3229 B.C
(C) 3230 B.C (D) 3231 B.C

08. Ans: (C)

Solution: The year of birth of Nicholas

$$\begin{array}{ccc} 25 & 21 & 23 \\ \downarrow & \downarrow & \downarrow \\ 2 & 3 & 6 \end{array} \Rightarrow 3227$$

The ages of Nicholas, Vladimir and Rasputin are in A.P

The ages of Nicholas	Vladimir	Rasputin
3227	?	3233

$$\therefore \text{Vladimir age} = \frac{\text{Nicholas}+\text{Rasputin}}{2}$$

$$=\frac{3227+3233}{2} = 3230 \text{ B.C}$$

09. Recent studies have highlighted the harmful effects of additives in food (colors, preservatives, flavor enhancers etc.). There are no synthetic substances in the foods we produce at Munchon Foods - we use only natural ingredients. Hence you can be sure you are safeguarding your family's health when you buy our products, says Munchon Foods. Which of the following, if true, would most weaken the contention of Munchon Foods?

(A) Some synthetic substances are not harmful
(B) Some natural substances found in foods can be harmful
(C) Food without additives is unlikely to taste good
(D) Munchon Foods produces only breakfast cereals

09. Ans: (B)

Sol: Munchon's contention is that buying their products safeguards health. To weaken that argument we can show that, for some reason, their foods might not be healthy.
So think about an alternative cause

10. To open a lock, a key is taken out of a collection of n keys at random. If the lock is not opened with this key, it is put back into the collection and another key is tried. The process is repeated again and again. It is given that with only one key in the collection, the lock can be opened. The probability that the lock will open in 'n^{th}' trail is _____

(A) $\left(\frac{1}{n}\right)^n$ (B) $\left(\frac{n-1}{n}\right)^n$
(C) $1-\left(\frac{n-1}{n}\right)^n$ (D) $1-\left(\frac{1}{n}\right)^n$

10. Ans: (C)

Sol: Probability that the lock is opened in a trail is $\frac{1}{n}$ (since there is exactly one key, which opens the lock)

$\therefore$ The chance that the lock is not opened in a particular trail = $1-\frac{1}{n}$

P(lock is opened in n^{th} trial) = 1– P(lock is not opened in n trials)

$$=1-\left[1-\frac{1}{n}\right]^n = 1-\left[\frac{n-1}{n}\right]^n$$

Mechanical Engineering

ONE MARK QUESTIONS (Q.11 – Q.35)

11. $\int_{-2}^{2}|1-x^4|dx =$ ________

11. Ans: 12

Sol: $\int_{-2}^{2}|1-x^4|dx = 2\int_{0}^{2}|1-x^4|dx$

($\because |1-x^4|$ is even function)

$= 2\{\int_0^1 (1-x^4)dx - \int_1^2 (1-x^4)dx\}$

$= 12$

12. A fair coin is tossed until one of the two sides occurs twice in a row. The probability that the number of tosses required is even is ________.

12. Ans: $\frac{2}{3}$

Sol: A = {HH, HTHH, HTHTHH, ...}
B = {TT, THTT, THTHTT, ...}

$P(A) = \frac{1}{3}$ & $P(B) = \frac{1}{3}$

$P(A \text{ or } B) = \frac{2}{3} = 0.66$

13. If δ_1 and δ_2 are boundary layer thicknesses at a point *x* from the leading edge on a flat plate when the Reynolds numbers are 225 and 400 respectively, then the ratio of δ_1 to δ_2 is ______.

13. Ans: 1.33 (range 1.3 to 1.4)

Sol: $\delta \propto \frac{1}{\sqrt{R_{e_x}}}$ (At given distance '*x*')

$$\frac{\delta_1}{\delta_2} = \sqrt{\frac{R_{e_2}}{R_{e_1}}}$$

$$\frac{\delta_1}{\delta_2} = \sqrt{\frac{400}{225}} = \frac{20}{15} = 1.33$$

14. Two reservoirs are connected by two pipes 'A' and 'B' of identical diameter and length in parallel. If the friction factor of 'A' is 2 times that of 'B' the ratio of the discharge in 'A' to that of in 'B' is_______

14. Ans: 0.707 (range 0.70 to 0.71)

Sol: In parallel pipe arrangement;

$h_{f_A} = h_{f_B}$

$$\frac{f_A . l_A . Q_A^2}{12.1 \times d_A^5} = \frac{f_B l_B . Q_B^2}{12.1 \times d_B^5}$$

Given $d_A = d_B$; $l_A = l_B$, $f_A = 2f_B$

$$\left(\frac{Q_A}{Q_B}\right)^2 = \frac{f_B}{f_A}$$

$$\frac{Q_A}{Q_B} = \sqrt{\frac{f_B}{f_A}} = \sqrt{\frac{f_B}{2f_B}} = \sqrt{\frac{1}{2}} = 0.707$$

15. The maximum wavelength corresponding to radiation at a temperature of 2000 K is ________ (in μm)

15. Ans: 1.449 μm

Sol: $\lambda_{max} \times T = 2898$ μm K;
Hence, $\lambda_{max} = 2898/2000 = 1.449$ μm.

16. If the probability of hitting a target is $\frac{1}{5}$ and if 10 shots are fired, what is the conditional probability that the target being hit atleast twice assuming that atleast one hit is already scored?
(A) 0.6999 (B) 0.624
(C) 0.892 (D) 0.268

16. Ans: (A)

Sol:

$$P(x \geq 2 | x \geq 1) = \frac{P(x \geq 2)}{P(x \geq 1)} = \frac{1 - q^n - npq^{n-1}}{1-q^n}$$

$$= \frac{1-\left(\frac{4}{5}\right)^{10} - 10\left(\frac{1}{5}\right)\left(\frac{4}{5}\right)^{9}}{1-\left(\frac{4}{5}\right)^{10}}$$

$= 0.6999$

17. For which value of α the following system of equations is inconsistent?

$3x + 2y + z = 10$
$2x + 3y + 2z = 10$
$x + 2y + \alpha z = 10$

(A) $\frac{7}{5}$ (B) $\frac{-7}{5}$
(C) $\frac{-5}{7}$ (D) $\frac{5}{7}$

17. Ans: (A)

Sol: $\begin{vmatrix} 3 & 2 & 1 \\ 2 & 3 & 2 \\ 1 & 2 & \alpha \end{vmatrix} = 0$

$\Rightarrow 3(3\alpha - 4) - 2(2\alpha - 2) + (4-3) = 0$

$\Rightarrow 5\alpha - 7 = 0$

$\therefore \alpha = \frac{7}{5}$

18. A Solid disc rolls from rest from the top of an incline of vertical height h. The speed of the centre of mass of the disc at the bottom of incline if rolling is without slipping is

(A) $\sqrt{2gh}$ (B) $\sqrt{\frac{10}{7}gh}$
(C) $\sqrt{\frac{1}{2}gh}$ (D) $\sqrt{\frac{4}{3}gh}$

18. Ans: (D)

Sol: Energy at the top = mgh

Energy at the bottom $= \frac{1}{2}mV^2 + \frac{1}{2}I\omega^2$

$$= \frac{1}{2}mV^2 + \frac{1}{2}\frac{1}{2}mR^2.\left(\frac{V}{R}\right)^2$$

$$= \frac{3}{4}mV^2$$

$$mgh = \frac{3}{4}mV^2$$

$$\Rightarrow V = \sqrt{\frac{4}{3}gh}$$

19. By increasing cross section area by 4% and decreasing the thickness by 2 % the percentage change in rate of heat transfer for same material and differential temperature is

(A) Increases by 6 %
(B) Decreases by 6%
(C) Increases by 2%
(D) Decreases by 2%

19. Ans: (C)

Sol:

$(dQ/Q) \times 100 = (dA/A) \times 100 - (dL/L) \times 100$
$= 4 - (2) = 2\ \%$

20. Consider the following statements:
The Fourier heat conduction equations

$Q = kA\,\frac{dT}{dx}$ *presumes*

1. Steady-state conditions
2. Constant value of thermal conductivity.
3. Uniform temperatures at the wall surfaces
4. One dimensional heat flow

Of these statements

(A) 1, 2 and 3 are correct
(B) 1, 2 and 4 are correct
(C) 2, 3 and 4 are correct
(D) 1, 3 and 4 are correct

20. Ans: (D)

Sol: In the Fourier equation "k" may considered as variable also.

21. In January, a car dealer predicted "Febrauary" demand as 200 cars but the actual demand turned out to be 235 cars. The forecast for the month of march using smoothing constant as 0.4 is
(A) 214 (B) 186
(C) 294 (D) 235

21. Ans: (A)
Sol:
New forecast = Forecast + α (forecast error)
Prediction = Forecast
$\Rightarrow F_{feb} = 200$; $D_{feb} = 235$
$F_{t+1} = F_t + \alpha (D_t - F_t)$
$F_{mar} = F_{feb} + \alpha (D_{feb} - F_{feb})$
$= 200 + 0.4 (235 - 200)$
$= 214$

22. In the basic EOQ model, annual demand is 10000 units, ordering cost is equal to Rs. 500 per order. If the Economic Order Quantity is 2000 units then the minimum inventory cost per annum is
(A) Rs. 10,000
(B) Rs. 500
(C) Rs. 2500
(D) Rs. 5000

22. Ans: (D)
Sol: At EOQ
Carrying cost / year = ordering cost / year
Total inventory cost per annum = carrying cost / year + ordering cost / year
= 2 × ordering cost /year
$$= 2\times\frac{10000}{2000}\times 500 = 5000$$
(or)
No. of orders (N)
$$= \frac{\text{Annual demand}}{\text{EOQ}} = \frac{10000}{2000} = 5$$
Minimum inventory cost / year = Total inventory cost / year at EOQ
= 2 × ordering cost /year
= 2 × 5 × 500 = Rs. 5000

23. Match the following
List – I
1. Martensite
2. Pearlite
3. Troosite
4. Sorbite

List – II
P. Coarse particles of cementite in ferrite phase
Q. Short needle shapes of grains
R. Alternate layers of ferrite and cementite
S. Fine particles of cementite in ferrite phase

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

23. Ans: (D)

24. A double parallel fillet weld of length 75mm and thickness 2.85mm. The yield stress of 200 MPa. The strength of weld with a factor of safety of 2.0 is
(A) 7556 N (B) 15112 N
(C) 21375 N (D) 10687 N

24. Ans: (B)

Sol: $$P = \left(\frac{S_{yt}}{2\times FS}\right)\times 0.707\times t\times 2L$$
(for double parallel fillet weld)
$$P = \frac{200}{2\times 2}\times 0.707\times 2.85\times 2\times 75$$
$\therefore$ P = 15112 N

25. The pattern material used for producing wave guides of radar system using casting process will be
(A) Plaster of paris
(B) Frozen Mercury
(C) Wax
(D) Polystyrene

25. Ans: (C)

Sol: Due to complex shape of the casting and possibility of reusability of the pattern the wax pattern with investment casting will be used for producing wave guides for radar system.

26. Diamond cutting tools are not recommended for machining of ferrous materials, because of
    (A) High frictional wear at the chip tool interface
    (B) High abrasive wear at the tool work interface
    (C) High diffusion wear at the chip tool interfaces
    (D) All of the above

26. Ans: (C)

Sol: During machining of ferrous materials, because of presence of atomic attraction between the carbon atoms of diamond tool and iron work piece, the diffusion wear is high.

27. Which of the following method is used for producing a 1mm × 1mm square hole with perfect square corners in a Tungsten carbide die
    (A) Ultrasonic machining method
    (B) Electric discharge machining method
    (C) Broaching operation
    (D) Electrochemical machining method

27. Ans: (A)

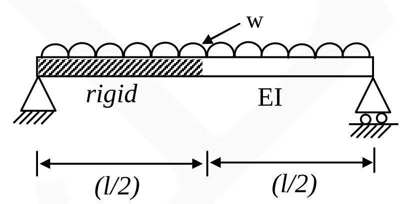
Sol: Broaching cannot be used because such a small size broaching tool cannot be made, EDM can be used but perfect corners cannot be made and ECM is not preferable for producing holes.

28. Relieving internal residual stresses, reducing brittleness and increasing toughness can achieved by
    (A) Carrying out preheating of joint
    (B) Carrying out the Post heating of weld bead
    (C) Removing the slag
    (D) All of the above

28. Ans: (B)

Sol: By carrying out the post heating in welding operation (It is like tempering heat treatment), it possible to relieve the internal residual stresses , reduce the brittleness and increase the toughness.

29. A beam simply supported at ends and subjected to udl throughout its length. Left half of the beam is rigid and right half is flexible with uniform flexural rigidity of EI. The bending moment at mid span is



(A) $\frac{w\ell}{2}$ (B) $\frac{w\ell^2}{8}$

(C) $\frac{w\ell^2}{16}$ (D) $\frac{w\ell^2}{32}$

29. Ans: (B)

Sol: The shear force and bending moment diagram are independent of EI values.

30. Hook's law is valid upto
    (A) Elastic limit
    (B) Proportionality limit
    (C) Plastic limit
    (D) Failure point

30. Ans: (B)

Sol: Upto proportinality limit stress is linearly proportional to strain. Therefore Hooke's law is perfectly valid

31. Z = f(x,y) and dz = Mdx + Ndy, then $\left(\frac{dy}{dx}\right)_z$ is given by

(A) $-\frac{M^2}{N}$ (B) $-\frac{N^2}{M}$

(C) $-\frac{M}{N}$ (D) $-\frac{N}{M}$

31. Ans: (C)

Sol: dz = Mdx + Ndy , [z = constant]

$\therefore$ dz = 0

$\Rightarrow$ Mdx + Ndy = 0

Ndy = – Mdx

$$\Rightarrow \left(\frac{dy}{dx}\right)_z = -\frac{M}{N}$$

32. Three gases are throttled at atmospheric pressure and temperature then which of the following gases exhibit a fall in temperature

(A) Air, CO_2, Helium

(B) N_2, O_2, Hydrogen

(C) CO_2, N_2, Neon

(D) Air, CO_2, O_2

32. Ans: (D)

Sol: All gases at room temperature and pressure have (μ > 0). Hence they suffer cooling when throttled.

Exceptions are hydrogen ; Helium and Neon ; they have a heating effect. As their maximum temperature of inversion are very much below room temperature.

33. To avoid leakage of refrigerant from the tubes of the refrigerant should have

(A) high density

(B) low density

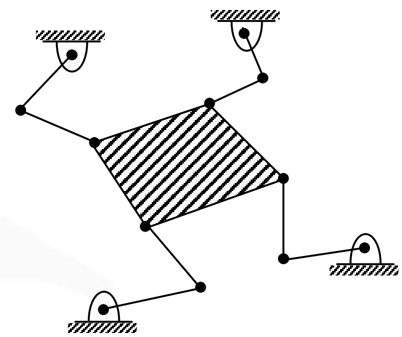
(C) high specific heat

(D) low specific heat

33. Ans: (A)

Sol: High density and refrigerant clings to tubes.

34. Degrees of freedom for the planer mechanism shown in below figure is



(A) 0 (B) 1 (C) 2 (D) 3

34. Ans: (D)

Sol: No of links, l = 10

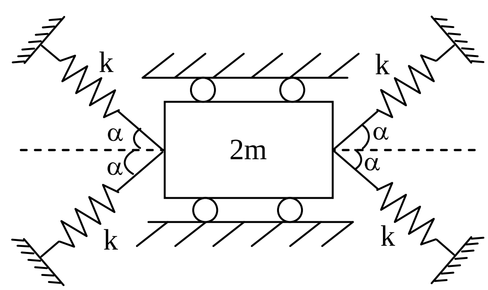
No of joints, J = 12 (all class 1 pairs)

No of degree of freedom = $3(l-1) - 2J$

= 3 (10 – 1) – 2 × 12

= 27 – 24 = 3

35. The Natural frequency (in rad/sec) for the spring mass system shown in figure is (all the springs are inclined to the direction of oscillation at an angle α = 45° and the amplitude of oscillation is small).



(A) $\sqrt{\frac{2k}{2m}}$ (B) $\sqrt{\frac{k}{2m}}$

(C) $\sqrt{\frac{4k}{2m}}$ (D) $\sqrt{\frac{8k}{2m}}$

35. Ans: (A)

Sol: When the spring is inclined to the direction of oscillation at an angle α. The equivalent stiffness is $k\cos^2\alpha = \frac{k}{2}$ ($\alpha = 45°$).

The four springs are parallel

$\therefore k_{eq} = 4\times\frac{k}{2} = 2k$

Natural frequency = $\sqrt{\frac{2k}{2m}} = \sqrt{\frac{k}{m}}$

TWO MARK QUESTIONS (Q.36 – Q.65)

36. Let f (x,y) = k xy – x^3y – xy^3 for (x, y) $\in R^2$, where 'k' is a real constant. The directional derivative of f(x,y) at the point (1,2) in the direction of unit vector $\frac{-i}{\sqrt{2}} - \frac{\vec{j}}{\sqrt{2}}$ is $\frac{15}{\sqrt{2}}$. Then the value of k is _____.

36. Ans: 4

Sol: (grad f). $\hat{a} = \frac{15}{\sqrt{2}}$

$\{[ky - 3x^2y - y^3]\,\bar{i} + [kx - x^3 - 3xy^2]\,\bar{j}\}.\left(\frac{-\bar{i}}{\sqrt{2}} - \frac{\bar{j}}{\sqrt{2}}\right) = \frac{15}{\sqrt{2}}$

$$\left[(2k-6-8)\,\bar{i} + (k-1-12)\,\bar{j}\right].\left[\frac{-\bar{i}}{\sqrt{2}} - \frac{\bar{j}}{\sqrt{2}}\right] = \frac{15}{\sqrt{2}}$$

$\therefore$ k = 4

37. Given the differential equation $y^1 = x - y$ with initial condition $y(0) = 0$. The value of $y(0.1)$ calculated numerically upto the third place of decimal by the 2nd order Runge-Kutta method with step size h = 0.1 is ____

37. Ans: 0.005

Sol: Given, $y^1 = x - y$

Also given $y(0) = 0$ and h = 0.1

$y(0.1) = ?$

Let $x_0 = 0$, $x_1 = x_0 + 1.h = 0 + 0.1 = 0.1$

The 2nd order Rungue-Kulta method is given by

$$y_1 = y(x_1) = y_0 + \frac{1}{2}(k_1 + k_2)$$

where $k_1 = h\,f(x_0, y_0)$ and

$k_2 = h\,f(x_0 + h,\ y_0 + k_1)$

$k_1 = (0.1)\,[x_0 - y_0] = (0.1)\,(0 - 0) = 0$

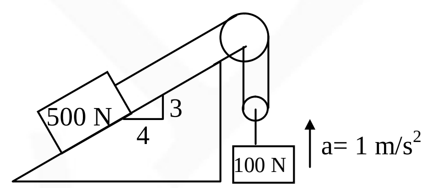
$k_2 = (0.1)\,[(x_0 + h) - (y_0 + k_1)]$

$= (0.1)\,[0 + 0.1 - (0 + 0)] = 0.01$

$y_1 = y(0.1) = 0 + \frac{1}{2}(0 + 0.01) = \frac{0.01}{2}$

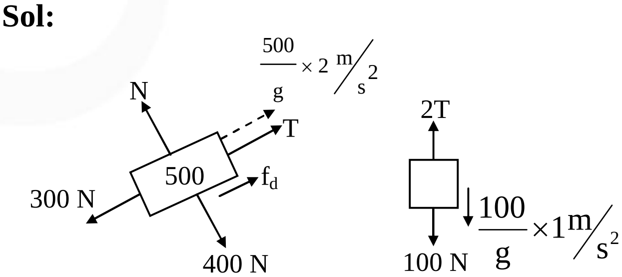
$= 0.005$

38. Find the value of co-efficient of dynamic friction between 500 N block of incline is __________ (Assume g = 10 m/sec^2)



38. Ans: 0.3625 (range 0.35 to 0.37)

Sol:



$T = \frac{100+10}{2} = 55$ N

$f_d = 300 - (100 + 55) = 145$ N

$f_d = \mu_d N$

$145 = \mu_d\,(400)$

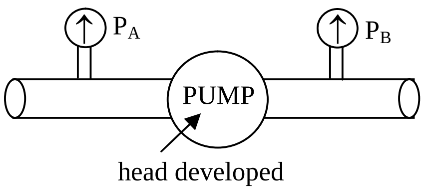
$\mu_d = 0.3625$

39. In a pump the suction and delivery pipes are of the same size and are at the same level. At a given discharge the loss of head between a point A on the suction side and a

point B on the delivery side is 3.0 m. if the pressure at point B is 120 kPa and the head developed by the pump is 10 m, the pressure at point A, in kPa is __________. (Water is the flowing fluid)

39. Ans: 51.33 kPa (range 51 to 52)

Sol: Apply Bernoulli's equation to pump



$$\frac{P_A}{\rho g}+Z_A+\frac{V_A^2}{2g}+\text{head developed}$$

$$=\frac{P_B}{\rho g}+Z_B+\frac{V_B^2}{2g}+H_{Loss}$$

Where head developed = Head raised = 10 m

Since pipes are same size

$V_A = V_B$ and $Z_A = Z_B$

$$\frac{P_A}{\rho g}+10=\frac{120\times10^3}{1000\times9.81}+3$$

$P_A = (12.23 + 3 - 10)\times\rho g$

$P_A = (5.234)(1000\times9.81)$

$= 51.33\times10^3\ N/m^2 = 51.33$ kPa

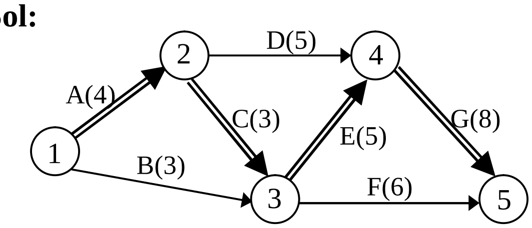
40. A project consists of 7 activities with the following data .

Activity	Predecessor	Duration (days)
A	-	4
B	-	3
C	A	3
D	A	5
E	B, C	5
F	B, C	6
G	D, E	8

The minimum time required to complete the project (in days) is ___________

40. Ans: 20 days

Sol:



Path	Duration (days)
A – D – G	4 + 5 + 8 = 17
A – C – E – G	4 + 3 + 5 + 8 = 20
B – E – G	3 + 5 + 8 = 16
B – F	3 + 6 = 9
A – C – F	4 + 3 + 6 = 13

Minimum time required to complete the project = 20 days

41. Stress at a point is given by stress tensor $\sigma=\begin{bmatrix}100 & 40\\40 & 40\end{bmatrix}$ MPa. Yield strength of material is 300 MPa. Operating factor of satey according to Guest theory of failure is __________

41. Ans: 2.5 (2.2 to 2.8)

Sol: $$\sigma_{1,2}=\frac{\sigma_x+\sigma_y}{2}\pm\sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$$

$$=\frac{100+40}{2}\pm\sqrt{\left(\frac{100-40}{2}\right)^2+40^2}$$

$\therefore\ \sigma_1 = 120$ MPa, $\sigma_2 = 20$ MPa

$$\tau_{max}=\left(\frac{\sigma_1-\sigma_2}{2}\right)\text{ or }\left(\frac{\sigma_1}{2}\right)\text{ or }\left(\frac{\sigma_2}{2}\right)$$

$= 50$ or 60 or $20 = 60$ MPa

Guest theory

$$\tau_{max}=\frac{\sigma_{yt}}{2\times FS}$$

$$60=\frac{300}{2\times FS}\Rightarrow FS=2.5$$

42. When measuring the effective diameter of a Metric external screw thread of 3.5mm pitch, a 35.5mm diameter cylindrical standard and 2.00mm wires were used. The micrometer readings over the standard and wires, and thread and wires used 18.8673 and 17.8242mm respectively. The thread Effective diameter in mm is ________

42. Ans: 31.4465 mm

Sol: The best wire size = P/2 sec(α/2)

= (3.5/2) sec (30) = 2.01 mm = 2.00mm

Micrometer reading = M = S + ($R_2 – R_1$)

= 34.4569mm

Effective diameter = M – (d + 0.5P tan(α/2)

= 34.4569 – (2 + 0.5 × 3.5 × tan30)

= 31.4465mm

43. A GO plug gauge is designed to inspect a hole by the machine operator. The L-limit and H-limit of the hole are 50.00mm and 50.30mm respectively. The gauge tolerance and wear allowance are taken as 10% of work tolerance. The H-limit of the GO gauge respectively in mm are _______

43. Ans: 50.06mm

Sol: Work tolerance = WT = 50.3 – 50 = 0.3mm

GT = WA = 10% of WT = 0.03mm

Actual Go size = 50.00

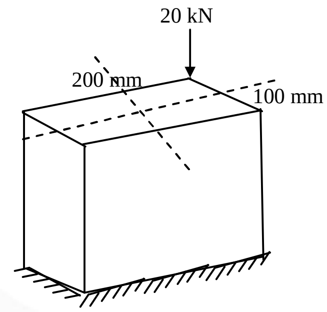
L – limit of Go gauge

= 50 + WA = 50.03mm

H-limit of Go gauge

= 50.03 + GT = 50.06mm

44. A column is loaded as shown in figure the maximum compressive stress developed in the column is _________



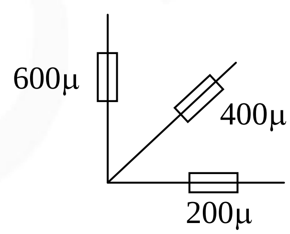
44. Ans: 7 MPa

Sol:

$$\sigma_{max} = \frac{20\times10^3}{200\times100} + \frac{20\times10^3\times100\times100}{\left(\frac{100\times200^3}{12}\right)} + \frac{20\times10^3\times50\times50}{\left(\frac{200\times100^3}{12}\right)}$$

= 1 + 3 + 3 = 7 MPa

45. The strain values of a rectangular strain rosette are as shown in figure. E = 200 GPa, μ = 0.3. The major principal stress developed in the beam is _______ MPa.



45. Ans: 145 MPa (range 144 to 146)

Sol: The major and minor principal strains are respectively

$\varepsilon_1 = 600\ \mu$ and $\varepsilon_2 = 200\ \mu$

Principal stresses are

$$\sigma_1 = \frac{E(\varepsilon_1 + \mu\varepsilon_2)}{1-\mu^2}$$

$$= \frac{200\times10^3(600\times10^{-6} + 0.3\times200\times10^{-6})}{(1-0.3^2)}$$

= 145 MPa

46. Air is entering a nozzle with negligible velocity. The ratio of exit pressure to inlet pressure is 1/6 and inlet temperature of air is 300 K. The exit velocity (in m/sec) is ________

46. Ans: 491.52 m/sec (range 490 to 492)

Sol: $\gamma = 1.4$ for air , $c_p = 1.005$ kJ/kgK

$$h_i + \frac{V_i^2}{2} = h_e + \frac{V_e^2}{2}$$

$V_i = 0$

$$V_e = \sqrt{2(h_i - h_e)} = \sqrt{2c_p(T_i - T_e)}$$

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

From adiabatic law

$$\frac{T_e}{T_i} = \left(\frac{P_e}{P_i}\right)^{\frac{\gamma-1}{\gamma}}$$

$$V_e = \sqrt{2c_pT_i\left(1 - \left(\frac{P_e}{P_i}\right)^{\frac{\gamma-1}{\gamma}}\right)}$$

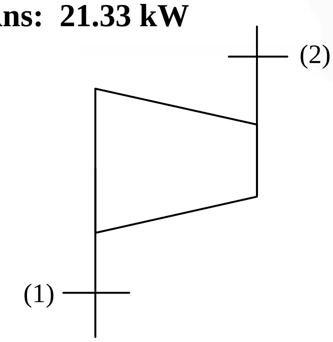
$$= \sqrt{2\times1005\times300\left(1 - \left(\frac{1}{6}\right)^{\frac{0.4}{1.4}}\right)}$$

= 491.52 m/sec

47. Air flows through an adiabatic compressor at 2 kg/sec. The inlet conditions are 1 bar and 310 K and exit conditions are 7 bar and 560 K. The irreversibility if T_0= 298 K (in kW) is _______

47. Ans: 21.33 kW

Sol:



P_1 = 1 bar, T_1 = 310 K ,
P_2 = 7 bar , T_2 = 560 K , T_0 = 298 K

Minimum work input

$$W_{min} = \dot{m}[(h_2 - h_1) - T_0(s_2 - s_1)]$$
$$= \dot{m}[c_p(T_2 - T_1) - T_0(s_2 - s_1)]$$

$$W_{actual} = \dot{m}\,c_p(T_2 - T_1)$$

Irreversibility = $W_{actual} - W_{min}$

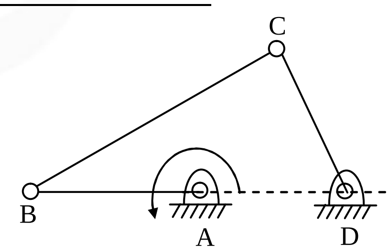
$$= \dot{m}\,T_0(s_2 - s_1)$$

$$= \dot{m}\,T_0\left(c_p\,\ell n\left(\frac{T_2}{T_1}\right) - R\,\ell n\left(\frac{P_2}{P_1}\right)\right)$$

$$= 2\times298\left(1.005\,\ell n\left(\frac{560}{310}\right) - 0.287\,\ell n\left(\frac{7}{1}\right)\right)$$

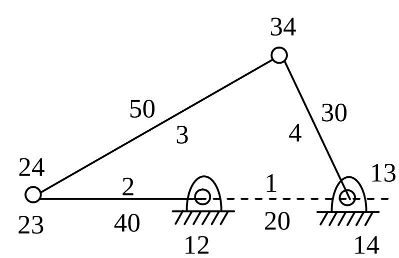
= 2 × 298 (0.5943 – 0.5585)
= 21.33 kW

48. Refer to the four bar mechanism shown in figure. AB = 40 cm, BC = 50 cm, DC = 30 cm, AD = 20 cm. At the instant when AB makes an angle of 180° with AD and rotates with an angular velocity of 3 rad/sec in counter clock wise direction. The angular velocity of the coupler link BC is _______________



48. Ans: 2 rad/sec

Sol:



Identify the instantaneous centers as shown in figure

ω_2 = 3 rad/sec

using Relative velocity for the instantaneous centre 23.

$V_{23} = (12-23)\,\omega_2 = (13-23)\,\omega_3$

$$\Rightarrow \omega_3 = \frac{12-23}{13-23}\times\omega_2$$

$$= \frac{40}{60}\times 3 = 2\,\text{rad/sec}$$

$\therefore$ Angular velocity of the coupler BC = 2 rad/sec

Note: (12 – 23) is the distance between the centres 12 and 23.

49. A mass of 1 kg attached at the end of a spring whose other end is fixed oscillates with a natural frequency of 20 Hz. A static force F when applied on the mass causes a deflection of 8 mm to the mass. The same force F when applied harmonically at a frequency 'f' leads to steady state vibration with an amplitude of 1 mm. The frequency of excitation 'f' (in Hz) is __________.

49. Ans: 60

Sol: Steady state amplitude is less than the static displacement X_{st}

$\therefore\ \omega > \omega_n$ and X is opposite to X_{st}

Given $X_{st} = 8$ mm, $X = 1$ mm, $f_n = 20$ Hz

We know

$$\frac{X}{X_{st}} = \frac{1}{1-\left(\frac{\omega}{\omega_n}\right)^2}$$ (Un-damped forced vibration)

$$\frac{-1}{8} = \frac{1}{1-\left(\frac{\omega}{\omega_n}\right)^2}$$

$$\left(\frac{\omega}{\omega_n}\right)^2 = 9$$

$\Rightarrow \omega = 3\omega_n$

$f = 3f_n$

$= 3\times 20 = 60$ Hz

So the frequency of the excitation force, f = 60 Hz

50. In a counter flow heat exchanger the cold fluid and hot fluids have mass flow rate of 2 kg/sec and 4 kg/sec with specific heats of 1 kJ/kgK and 0.5 kJ/kgK respectively. The overall Heat transfer coefficient is 150 W/m^{2}K, surface area is 20 m^2. If the hot fluid enters at 100 ^{0}C and cold fluid leaves at 45 ^{0}C, then rate of heat transfer is ________ (in kW) .

50. Ans: 165 kW (range 164.5 to 166)

Sol: LMTD method fails when $m_h c_h = m_c c_c$; but when LMTD fails use GMTD which either of end temperature differences. Hence Mean temperature difference is 100 – 45 = 55 ^{0}C.

$\Delta\theta_m = \Delta\theta_1 = \Delta\theta_2$

$Q = U\,As \times LMTD$

$= 150\times 20\times 55 = 165$ kW

51. Let w (y_1, y_2) be the wronskian of two linearly independent solutions y_1 and y_2 of the equation, $y'' + p(x)\,y' + Q(x)\,y = 0$. The product of w(y_1, y_2).p(x) =

(A) $y_2y_1'' - y_1y_2''$ (B) $y_1y_1' - y_2y_2'$

(C) $y_1y_2'' - y_2'y_1''$ (D) $y_1'y_2' - y_1''y_2''$

51. Ans: (A)

Sol: $y_1'' + p(x)y_1' + Q(x)y_1 = 0$.......(1)

$y_2'' + p(x)y_2' + Q(x)y_2 = 0$.......(2)

(1) × y_2 – (2) × y_1

$\Rightarrow p(x)\ \left(y_1'y_2 - y_1y_2'\right) = y_2''y_1 - y_1''y_2$

$\therefore$ w (y_1, y_2) p(x) = $y_1''y_2 - y_2''y_1$

52. If $X_r = \cos\left(\frac{\pi}{3^r}\right) + i\sin\left(\frac{\pi}{3^r}\right)$ for r = 1, 2, 3, ... Then X_1. X_2. X_3 .... (upto infinity) equal to (Where, i = $\sqrt{-1}$)

(A) 1 + i (B) 1

(C) i (D) $\frac{1}{2} + i\frac{\sqrt{3}}{2}$

52. Ans: (C)

Sol: $X_r = \cos\left(\frac{\pi}{3^r}\right) + \sin\left(\frac{\pi}{3^r}\right) = e^{i\left(\frac{\pi}{3^r}\right)}$,

r = 1, 2, 3, ...

$X_1. X_2. X_3 ......\quad e^{i\pi\left(\frac{1}{3}+\frac{1}{3^2}+\frac{1}{3^3}+.....\right)} = e^{\frac{i\pi}{2}} = i$

53. Let M be the matrix $\begin{bmatrix} 2 & 3 \\ 1 & -1 \end{bmatrix}$. Which of the following matrix equations does M satisfy.

(A) $M^3 + 3M + 5I = 0$
(B) $M^3 - M^2 - 5M = 0$
(C) $M^3 - 3M^2 + M = 0$
(D) $M^2 - M + 5I = 0$

53. Ans: (B)

Sol: The characteristic equation is

$$\lambda^2 - \lambda - 5 = 0$$

we have $M^2 - M - 5I = 0$ (using cayley Homilton theorem)

Multiplying both sides by M.

we get, $M^3 - M^2 - 5M = 0$

54. The chezy coefficient of a wide rectangular open channel is 60. The model scale ratio is 1:64. The chezy's coefficient of model river is

(A) 60
(B) 30
(C) 7.5
(D) Data insufficient

54. Ans: (A)

Sol: $V = C\sqrt{RS} \rightarrow$ Chezy's formula

$$F_r = \frac{V}{\sqrt{gy}}.$$

$$(F_r)_m = (F_r)_p$$

$$\left(\frac{V}{\sqrt{gy}}\right)_m = \left(\frac{V}{\sqrt{gy}}\right)_p$$

$$V_r = \sqrt{g_r}.\sqrt{y_r} = \sqrt{g_r}.\sqrt{L_r}$$

$$C_r = \frac{V_r}{\sqrt{R_r S_r}} = \frac{\sqrt{g_r}.\sqrt{L_r}}{\sqrt{L_r.g_r}} = \frac{\sqrt{g_r}}{\sqrt{g_r}}$$

'C' is independent of scale ratio

$\therefore C_m = C_p$

55. In Lumped heat capacity Analysis for limiting condition , the ambient temperature is 300^0C , and initial temperature is 30^0C. For what value of Fourier number is the temperature recorded by the thermocouple is one fifth of ambient temperature?

(A) 21.94
(B) 1.177
(C) 0.5115
(D) Data Insufficient biot number value missing.

55. Ans: (B)

Sol: At limiting condition biot number is 0.1.

Hence $ln(T - T_\infty / T_0 - T_\infty) = -bi \times F_o$

60 – 300/30 – 300 = 24 / 27 = 0.88888

At limiting condition, biot no. = 0.1

Hence F_o = 1.177

56. When cylinder is insulated inside with a material of thermal conductivity 1/10 of the parent material having same radial thickness (which is never equal to r and always less than r) , then which of the following statements are correct?

(A) heat transfer increases upto critical radius beyond which it decreases
(B) heat transfer decreases upto critical radius beyond which it increases
(C) Heat transfer increases since its critical radius is 0
(D) Heat Transfer always decreases

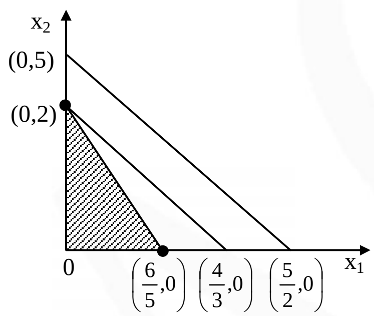
56. Ans: (D)

Sol: Critical radius is that outer radius where total thermal resistance offered is minimum applicable to cylinders insulated outside only since conduction resistance increases and convection resistance decreases.

When cylinders are insulated inside both conductive and convective resistance increases and total resistance increases which indicates the decrease in heat transfer always.

57. Consider the following LPP
Max Z = $2x_1 + 5x_2$
Subject to
$3x_1 + 2x_2 \le 4$
$5x_1 + 3x_2 \le 6$
$2x_1 + x_2 \le 5$
$x_1, x_2 \ge 0$
the solution to the given LPP is
(A) Infeasible
(B) Unique optimal
(C) Multiple optimal
(D) Degenerate

57. Ans: (D)
Sol:



$Z_{max} = 2x_1 + 5x_2$
$Z_{(0,0)} = 0$
$Z_{(0,2)} = 2(0) + 5(2) = 10$
$Z_{(6/5,\,0)} = 2\left(\frac{6}{5}\right) + 5(0) = \frac{12}{5}$
$x_1 = 0$, $x_2 = 2$
$Z_{max} = 10$

58. A conical thrust Bearing rotating at 100 rpm is subjected to a thrust load of 10kN. Power lost in watts, if face width 100m, inner and outer diameters are 200mm and 300mm respectively. Assume fluid friction as 0.08.
(A) 2094 W (B) 2121 W
(C) 1047 W (D) 1061 W

58. Ans: (B)
Sol: Uniform pressure theory is used for bearings

$$\sin\alpha = \frac{R-r}{b} = \frac{150-100}{100} = 0.9$$

$\Rightarrow \alpha = 30°$

$$T_f = \frac{2}{3}\frac{\mu W}{\sin\alpha}\frac{(R^3 - r^3)}{(R^2 - r^2)}$$

$$= \frac{2}{3} \times \frac{0.08\times 10\times 10^3}{\sin 30} \times \frac{(0.15^3 - 0.1^3)}{(0.15^2 - 0.1^2)}$$

$= 0.2027\times 10^3$ N-mm

$$P = \frac{2\pi N T_f}{60}$$

$$= \frac{2\times\pi\times 100\times 0.2027}{60} = 2121\,W$$

59. During welding operation with heat supply rate of 14kW, the area of weld bead is $40mm^2$ and welding speed of 100mm/min. if the heat required for melting of weld bead is $0.1kJ/m^3$, the welding process used is
(A) Gas welding
(B) Arc welding
(C) Resistance welding
(D) None of the above

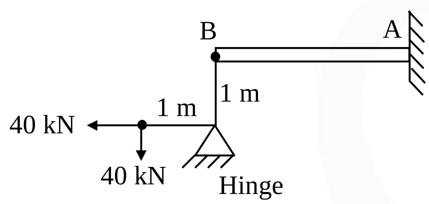
59. Ans: (B)
Sol: H.R / sec = [(area × velocity) /60]× 0.1
= 6.67 kJ/sec
Efficiency of welding process
= 6.67 / 14 = 47.61%
Based on the efficiency, the welding process used is Arc welding process
Efficiency of arc welding is 45 to 55%

60. When straight tapered sprue is used in the gating system, the pressure at entry, middle height and exit of the sprue respectively are
(A) P_{atm}, + ve gauge & P_{atm}
(B) P_{atm}, – ve gauge & P_{atm}
(C) P_{atm}, zero gauge & P_{atm}
(D) P_{atm} throughout

60. Ans: (A)

Sol: When parabolic sprue is used, the pressure all along length of the sprue is atmospheric and hence it avoids the aspiration effect. But it is difficult to manufacture. Due to this straight tapered sprue is used so that pressure at entry and exit is equal to atmospheric and in between the pressure is greater than atmospheric or +ve gauge pressure, hence it is avoiding aspiration effect and manufacture is also easier.

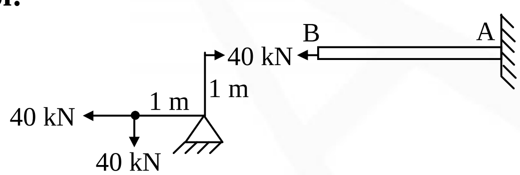
61. A member AB is made of steel and 1 m long the width of the bar is 200 mm and thickness is 50 mm. It is pulled by a lever as shown. Determine elongation of bar, use E = 200 GPa



(A) 0.02 mm (B) 0.04 mm
(C) 0.06 mm (D) 0.08 mm

61. Ans: (A)

Sol:



$$\delta\ell \text{ of AB} = \frac{P\ell}{AE} = \frac{40\times10^3\times1000}{200\times50\times200\times10^3}$$

$\therefore\ \delta\ell = 0.02$ mm

62. Gas is being pumped into a spherical balloon at a rate of 100 cubic metres per minute. When the radius r = 10 metres at what rate in m^2/minute is the surface area changing

(A) 5π (B) 10 (C) 10π (D) 20

62. Ans: (D)

Sol:

$V = \frac{4}{3}\pi r^3$ = volume of sphere

$$\frac{dv}{dt} = \frac{4}{3}\pi r^2 \times 3\frac{dr}{dt}$$

$$\frac{dv}{dt} = 4\pi r^2 \times \frac{dr}{dt}$$

$$100 = 4\pi\times10^2\times\frac{dr}{dt}$$

$$\frac{dr}{dt} = \frac{1}{4\pi}$$

$S = 4\pi r^2$ = surface area

$$\frac{dS}{dt} = 2\times4\pi r\times\frac{dr}{dt}$$

$$= 8\pi r\times\frac{dr}{dt}$$

$$= 8\pi\times10\times\frac{1}{4\pi} = 20\frac{\text{metre}^2}{\text{min}}$$

63. In a natural gas pipe line network at two different locations A and B. The measurements gave P_A = 0.25 MPa , P_B = 0.27 MPa , T_A = 302 K, T_B = 310 K. Assume natural gas behaves like an local gas with c_p = 29 kJ/kmolK. The flow is from

(A) A to B
(B) B to A
(C) No flow
(D) cannot be determined

63. Ans: (A)

Sol: Processes happen in a direction of increase in entropy

$$S_B - S_A = c_p\, ln\left(\frac{T_B}{T_A}\right) - R ln\left(\frac{P_B}{P_A}\right)$$

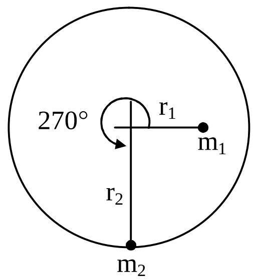
$$= 29\,\ell n\left(\frac{310}{302}\right) - 8.314\,\ell n\left(\frac{0.27}{0.25}\right)$$

$= 0.7582 - 0.6398$

$= 0.1183$ kJ/kmol K

Direction is from A to B.

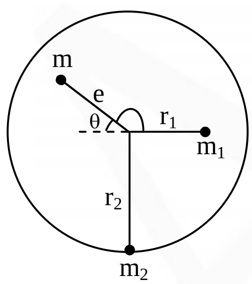
64. A thin eccentric disk of mass 1 kg is balanced by attaching two masses to it as shown in fig. mass one, m_1 = 3 gms at r_1 =10 cm while mass two, m_2 = 2 gms at r_2 = 20 cm. The radial position and angular position of the centre of mass of the disk with respect to m_1 are respectively



(A) 5 mm @ 126.87°
(B) 0.5 mm @ 126.87°
(C) 5 mm @ 143.13°
(D) 0.5 mm @ 143.13°

64. Ans: (B)

Sol: Assuming the C.G of the disk as shown in below figure



Considering equilibrium is horizontal and vertical directions.

me cosθ = m_1r_1 = 3 × 10 = 30gm cm

me sinθ = m_2r_2 = 2 × 20 = 40 gm cm

Solving, me = $\sqrt{30^2+40^2} = 50\,\text{gm cm}$

e = $\dfrac{50\,\text{gm cm}}{1000\,\text{gms}}$ = 0.05 cm = 0.5 mm

$\theta = \tan^{-1}\left(\dfrac{40}{30}\right)$ = 53.13°

Angular position with respect to

m_1 = 180° – 53.13° = 126.87°

65. A simple gear train is designed with a pinion of 20 teeth and a gear wheel of 60 teeth. They have a pressure angle of 20° and a module of 2mm. Both the pinion and gear have full dept involute tooth. Due to assembly constraints the centre distance was made equal to 80.8 mm what will be the effective pressure angle ?

(A) 20° (B) 21.5°
(C) 18° (D) 25°

65. Ans: (B)

Sol: For the pinion radius

$$r = \frac{mt}{2} = \frac{2\times 20}{2} = 20\,\text{mm}$$

Gear radius $R = \dfrac{mT}{2} = \dfrac{2\times 60}{2} = 60\,\text{mm}$

Designed centre distance

= 20 + 60 = 80 mm

Assembled centre distance = 80.8 mm

R + r = 80 mm

R′ + r′ = 80.8 mm

where R′ and r′ are effective radii .

We know for involute gears variation in centre distance will not alter the velocity ratio

$\therefore$ R′ / r′ = R / r = 3

$\Rightarrow$ R′ + r′ = 80.8 $\Rightarrow$ R′ = 60.6 mm

r′ = 20.2 mm

As the base circle radius remains unaltered the increase in centre distance leads to an increase in effective pressure angle

$\therefore R'\cos\phi' = R\cos\phi$

$$\Rightarrow \cos\phi' = \frac{R\cos\phi}{R'}$$

$$= \frac{60\cos 20^\circ}{60.6}$$

$\Rightarrow \phi$ = 21.5°