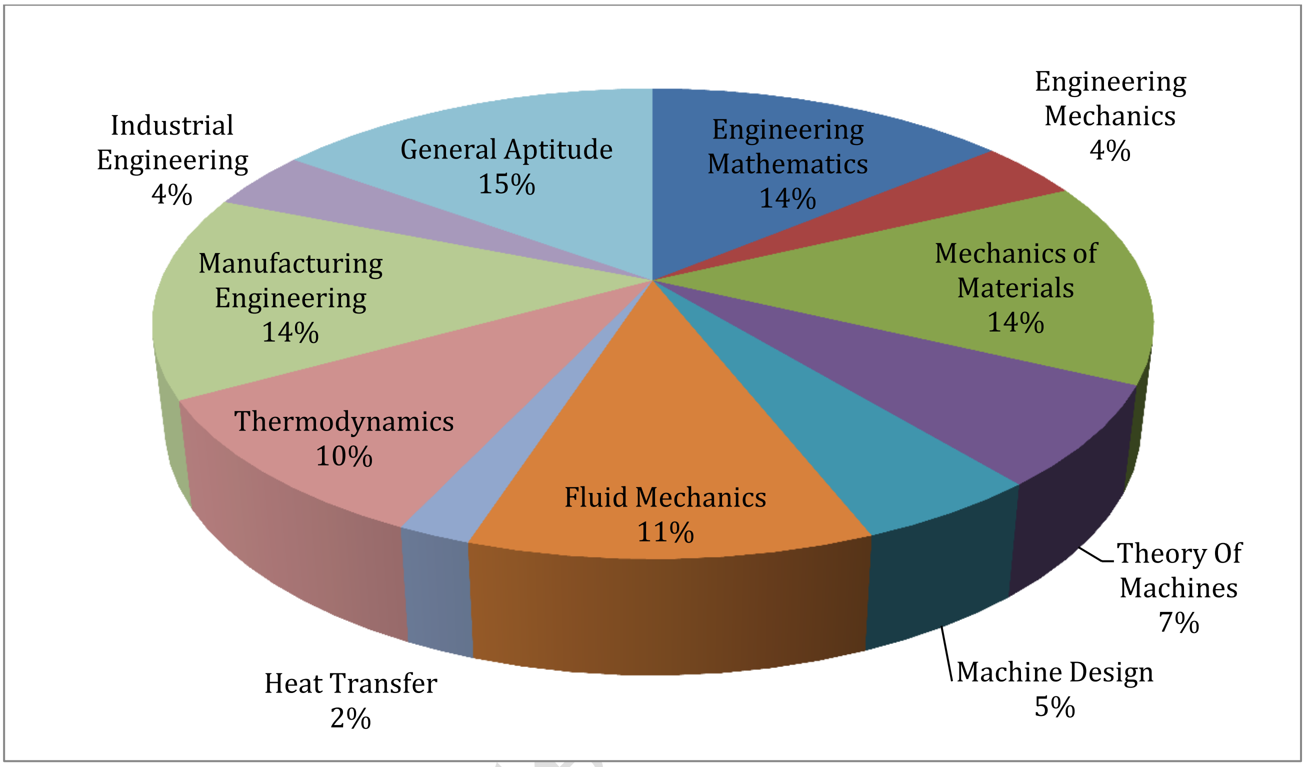
ANALYSIS OF GATE 2018

Mechanical Engineering



ME ANALYSIS-2018_3-Feb_Morning

SUBJECT	No. of Ques.	Topics Asked in Paper(Memory Based)	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 6 2 Marks: 4	Mean Value Theorem; Probability , Euler's Method, Rank, Analytic Function, Laplace Transform	Easy	14
Engineering Mechanics	1 Marks: 0 2 Marks: 2	Slider Crank Mechanism, Collision	Medium	4
Mechanics of Materials	1 Marks: 4 2 Marks: 5	Simple Stress Strains, Analysis of Shear Stress, Stress in Beams, Plain Stress	Medium	14
Theory Of Machines	1 Marks: 3 2 Marks: 2	Gear Strain	Medium	7
Machine Design	1 Marks: 1 2 Marks: 2	Bearing Capacity, Breaks	Easy	5
Fluid Mechanics	1 Marks: 3 2 Marks: 4	Peloton Wheels,	Medium	11
Heat Transfer	1 Marks: 0 2 Marks: 1	Conduction,	Easy	2
Thermodynamics	1 Marks: 2 2 Marks: 4	Entropy, IC Engines, Steady Flow Energy Equation	Medium	10
Manufacturing Engineering	1 Marks: 6 2 Marks: 4	ECM, Sheet Metal, Metal cutting	Tough	14
Industrial Engineering	1 Marks: 0 2 Marks: 2	Linear Program	Medium	4
General Aptitude	1 Marks: 5 2 Marks: 5	Geometry, TSD, Functions, Grammar, Numbers, Work, inference	Easy	15
Total	**65**			**100**
Faculty Feedback	Majority of the question were concept based. General Aptitude And Mathematics is Very Easy. Core Subject Questions were 50% easy, 30% medium and 20% tough.			

General Aptitude

GATE 2018 Examination* (Memory Based)

Mechanical Engineering

Test Date: 3-FEB-2018

Test Time: 9:00 AM 12:00 PM

Subject Name: Mechanical Engineering

General Aptitude

Q.1 - Q.5 Carry One Mark each.

1. Her___________ should not be confused with miserliness because she is ever willing to assist those in need.

(A) Cleanliness (B) Punctuality

(C) Frugality (D) Greatness

[Ans. C]*

Frugality is synonyms to miserliness

Frugality carries a positive connotation. It refers to the quality of being economical with money or food .

Miserliness is a negative word. It means excessive desire to save money or extreme meanness.

2. A rectangle becomes a square when its length and breadth are reduced by 10 m and 5 m respectively. During this process, the rectangle loses 650 m^2 of area. What is the area of the original rectangle in square meters?

(A) 1125 (B) 2250

(C) 2924 (D) 4500

[Ans. B]*

Rectangle initial length is l and breath is b. If l is reduced by 10 m and breath reduced by 5m then it becomes square.

So, 1^{st} condition,

$l - 10 = b - 5$

$l - b = 5$

$l \times b = A \cdots (i)$

Given, initial,

2^{nd}condition,

$(l - 10)(b - 5) = A - 650$

$lb - 10b - 5l + 50 = A - 650$

$A - 10b - 5l = A - 700$

$10b + 5l = 700$

$10b + 5(b + 5) = 700$

$15b + 25 = 700$

$15b = 700 - 25$
$15b = 6.75 \Rightarrow b = 45m$
$l = 45 + 5 = 50m$
Area of original rectangle $= 45 \times 50 = 2250\ m^2$

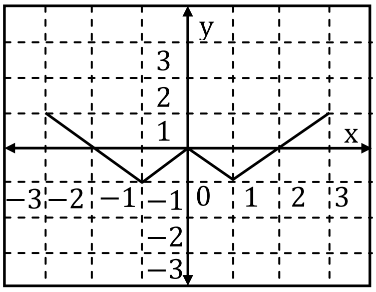
3. A number consists of two digits. The sum of the digits is 9. If 45 is subtracted from the number, its digits are interchanged. What is the number?
(A) 63 (B) 72
(C) 81 (D) 90
[Ans. B]*
Let two digit no is xy
$x + y = 9 \cdots (i)$
$10x + y - 45 = 10y + x$
Or
$x - 5 = y$
$x - y = 5 \cdots (ii)$
Adding (i) and (ii)
$x = 7$
Subtracting(i) and (ii)
$y = 2$
Therefore the number is 72

4. "Going by the _________ that many hands make light work, the school _________ involved all the students in the task"
The words that best fill the blanks in the above sentence are
(A) Principle , Principal (B) Principal, Principle
(C) Principle, Principle (D) Principal, Principal
[Ans. A]*
Principle –A moral rule /belief
Principle –The person in-charge of an education institution

5. Seven machines take 7 minutes to make 7 identical toys. At the same rate, how many minutes would it take for 100 machines to make 100 toys?
(A) 1 (B) 7
(C) 100 (D) 700
[Ans. B]*
7 machines → 7 toys → 7 minutes
1 machine → 1 toy → 7 minutes
Because one machine takes 7 minutes for making 1 toy.
So, 100 machines will take 7 minute for making 100 toys

Q.6 - Q.10 Carry Two Mark each.

6. Which of the following functions describe the graph shown in the below figure?



(A) $y = \left||x| + 1\right| - 2$ (B) $y = \left||x| - 1\right| - 1$

(C) $y = \left||x| + 1\right| - 1$ (D) $y = \left||x - 1| - 1\right|$

[Ans. B]*

x	0	± 1	± 2
y	0	-1	0

Solving through options,

(a) $y = \left||x| + 1\right| - 2$

Putting, $x = 1$

$y = 2 - 2 = 0$ Not satisfied

(b) $y = \left||x| - 1\right| - 1$

Putting, $x = 1$

$y = |1 - 1| - 1$

$y = -1$ satisfied

(c) $y = \left||x| + 1\right| - 1$

Putting, $x = 1$

$y = |1 + 1| - 1$

$y = +1$ Not satisfied

(d) $y = ||x - 1| - 1|$

Putting , $x = 1$

$y = ||1 - 1| - 1|$

$y = |0 - 1|$

$y = 1$ Not satisfied

7. Given that a and b are integers and $a + a^2b^3$ is odd, which one of the following statements is correct?

(A) a and b are both odd (B) a and b are both even

(C) a is even and b is odd (D) a is odd and b is even

[Ans. D]*

Given, a and b are integer

$a + a^2b^3$ is odd

$a(1 + ab^3)$ is odd

Multiplication of odd and odd number is odd.

So, a is odd and $1 + ab^3$ is odd.

$1 + ab^3$ is odd, so ab^3 will be even.

Because a is odd so for ab^3 to be even b must be even.
So, a is odd and b is even

8. From the time the front of a train enters a platform, it takes 25 seconds for the back of the train to leave the platform, while travelling at a constant speed of 54 km/h. At the same speed, it takes 14 seconds to pass a man running at 9 km/h in the same direction as the train. What is the length of the train and that of the platform in meters, respectively?

(A) 210 and 140
(B) 162.5 and 187.5
(C) 245 and 130
(D) 175 and 200

[Ans. D]*

Train speed =54 km/h
Time =25sec for travelling length of train and length of platform man speed=9 km/h
Relative speed of train with respect to man=45km/h
Time to cross the man=14sec
So, length of train = time × speed

$= 14 \times 45 \times \frac{5}{18}$

Length of train = 35 × 5 m = 175 m
Length of platform + length of train = speed × time

$= 54 \times \frac{5}{18} \times 25 = 15 \times 25 = 375$ m

Length of platform = 375 − 175 = 200 m

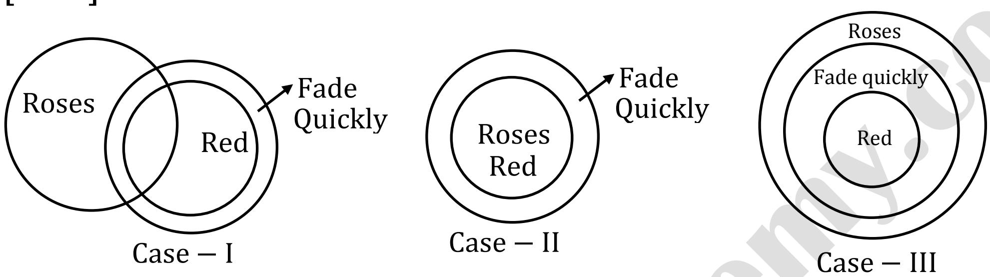
9. For integers a, b and c, what would be the minimum and maximum values respectively of $a + b + c$ if $\log|a| + \log|b| + \log|c| = 0$?

(A) −3 and 3
(B) −1 and 1
(C) −1 and 3
(D) 1 and 3

[Ans. A]*

$\log|a| + \log|b| + \log|c| = 0$
it is possible only,
If |a|, |b|and |c|all are equal to 1.
So, a, b, c, may be $\pm 1, + \pm 1, \pm 1$ respectively.]
For minimum value all three will be − 1.
So, minimum value = −3
For maximum value all three will be + 1,
So, maximum value = +3.

10. Consider the following three statements:
(i) Some roses are red.
(ii) All red flowers fade quickly.
(iii) Some roses fade quickly.
Which of the following statements can be logically inferred from the above statements?
(A) If (i) is true and (ii) is false, then (iii) is false.
(B) If (i) is true and (ii) is false, then (iii) is true.
(C) If (i) and (ii) are true, then (iii) is true.
(D) If (i) and (ii) are false, then (iii) is false.
[Ans. C]*



Technical

Q.1 - Q.25 Carry One Mark each.

1. A grinding ratio of 200 implies that the
   (A) Grinding wheel wears 200 times the volume of the material removed.
   (B) Grinding wheel wears 0.005 times the volume of the material removed.
   (C) Aspect ratio of abrasive particles used the grinding wheel is 200.
   (D) Ratio of volume of abrasive particle to that of grinding wheel is 200.
   [Ans. B]

$$\text{Grinding ratio} = \frac{\text{Volume of work material removed}}{\text{Volume of wheel wear}}$$

Volume of wheel wear = 0.005

2. Using the Taylor's tool life equation with exponent n = 0.5, if cutting speed is reduced by 50%, the ratio of new tool life to original tool lie is?
   (A) 4 (B) 2
   (C) 1 (D) 0.5
   [Ans. A]

$n = 0.5\ V_1\ V_2 = V_1/2$

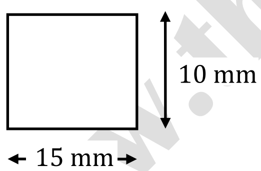
$T_1\ \ T_2$

$$V_1 T_1^n = V_2 T_2^n \frac{V_1}{V_2} = \left(\frac{T_2}{T_1}\right)^N$$

$$(2)^{\frac{1}{0.5}} = \frac{T_2}{T_1} = 4$$

3. A steel column of rectangular section (15 mm × 10 mm) and length 1.5 m is simply supported at both ends. Assuming modulus of elasticity, E = 200 GPa for steel, the critical axial load (in kN) is ________ (correct to two decimal places).
   [Ans. *]Range: 1.00 to 1.20

Given, L=1.5 m



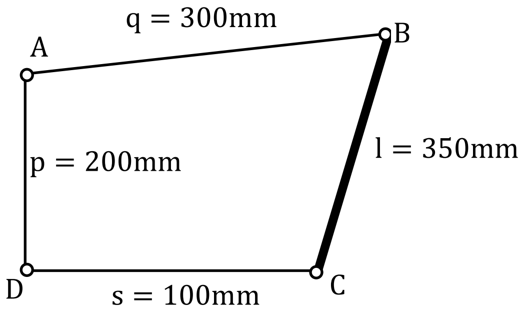
E = 200 GPa

$$P_{cr} = \left(\frac{\pi^2 EI}{L^2}\right)$$

$= 1.09$ kN

4. A four bar mechanism is made up of links of length 100, 200, 300, and 350 mm. If the 350 mm link is fixed, the number of links that can rotate fully is ________.

[Ans.] Range:1 to 1*



$s = 100, p = 200, l = 350, q = 300$

$(s + l) = 350 + 100 = 450 < (p + q)$

$450 < 200 + 300$

$450 < 500$

Grashof law is satisfied.

350 mm link is fixed

Then, shortest link=100 mm is adjacent to fixed, will give crank only.

5. In a linearly hardening plastic material, the true stress beyond initial yielding

(A) Increases linearly with true strain.

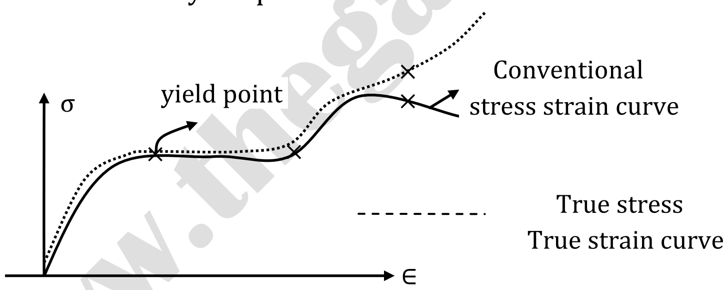
(B) Decreases linearly with true strain.

(C) First increases linearly and then decreases linearly with the true strain.

(D) Remains constant.

[Ans. A]

Constant after yield point



In strain hardening region, True stress is increasing with true strain

6. According to the Mean Value Theorem, for a function f(x) in the interval [a, b], there exists a value ξ in the $\int_a^b f(x)\,dx$ is =

(A) $f(\xi)(b - a)$

(B) $f(b)(\xi - a)$

(C) $f(a)(b - \xi)$

(D) 0

[Ans. A]

For a function $f(x) \epsilon (a, b)$, if there exists a value $'\xi'$

Then according to mean value theorem of integrals

$$\frac{1}{b-a}\int_a^b f(x)dx = f = (\xi)$$

$$\Rightarrow \int_a^b f(x)dx = (b-a)f(\xi)$$

7. For a two-dimensional incompressible flow field given by $\vec{u} = A(x\hat{i} - y\hat{j})$, where A>0, which one of the following statements is FALSE?
(A) It satisfies continuity equation.
(B) It is unidirectional when $x \to 0$ and $y \to \infty$.
(C) Its streamlines are given by $x = y$.
(D) It is irrotational.

[Ans. C]

$\vec{V} = A(x\hat{i} - y\hat{j})$ $A > 0$

$\Rightarrow u = Ax$

$v = -Ay$

$\Rightarrow \frac{\partial u}{\partial x} = A$

$\frac{\partial u}{\partial y} = -A$

$\Rightarrow \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = A - A$

$\Rightarrow \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$

i. e the given velocity vector satisfies the 2D continuity equation for incompressible fluid therefore first statement is true

Also $\frac{\partial v}{\partial x} = 0$

$\frac{\partial u}{\partial y} = 0$

$\Rightarrow \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} = 0$

i. e w_2 i.e. flow is ir-rotational hence 2nd statement is also true.

The streamline equation for the flow is

$\frac{dx}{u} = \frac{dy}{v}$

$\Rightarrow \frac{dx}{Ax} = \frac{dy}{-Ay}$

$\Rightarrow \ln x = -\ln y + c$

$\Rightarrow xy = k$

Hence 3rd statement is false

Based on the expression $\vec{V} = A(xi - yj)$when $x \to 0$, motion is nearly along y axis hence flow is 1D for all value of y and similarly when $y \to \infty$

$u \ll v$

⇒ Again flow is unidirectional thus 4th statement is also true
Since out of 4 statements only 3rd statement is false, and we have to choose incorrect statement,(C) is the answer

8. If the wire diameter of a compression helical spring is increased by 2%, the change in spring stiffness(in %) is ________ (correct to two decimal places)
[Ans. *] Range: 8.00 to 8.50

$$k = \frac{Gd^4}{8D^3N}$$
$$d_1 = d$$
$$d_2 = 1.02\ d$$
$$\Rightarrow \frac{k_2 - k_1}{k_1} \times 100 = 8.243\%$$

9. F(z) is a function of the complex variable $z = x + iy$ given by $F(z) = iz + k\,Re(z) + i\,lm(z)$. For what value of k will F(z) satisfy the Cauchy-Riemann equations?
(A) 0
(B) 1
(C) −1
(D) y
[Ans. B]

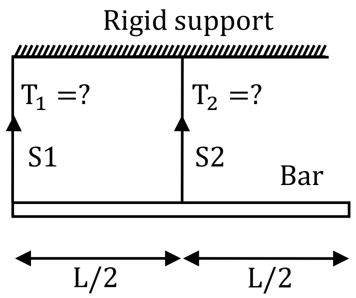
$$f(z) = i(x + i\,y) + k(x) + i\,y$$
$$= ix - y + kx + i\,y$$
$$f(z) = \underbrace{(kx - y)}_{u} + i\,\underbrace{(x + y)}_{v}$$

C-R equations are,
$$\frac{\partial u}{\partial x} = \frac{\partial V}{\partial y}; k = 1$$
$$\left[\frac{\partial u}{\partial x} = \frac{-\partial V}{\partial c}; -1 = -(1)\right]$$

10. The height (in mm) for a 125 mm sine bar to measure a taper of 27°32’ on a flat work piece is ________ (correct to three decimal places).
[Ans. *]Range: 57.000 to 58.000

$$\theta = 27°32' = 27 + \frac{32}{60} = 27.533°$$
$$\sin\theta = \frac{h}{L}$$
$$125 \times \sin 27.533 = 57.782\ mm$$

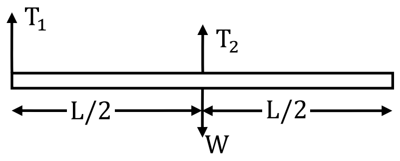
11. A bar of uniform cross section and weighing 100 N is held horizontally using two massless and inextensible strings S1 and S2 as shown in the figure.



(A) $T_1 = 100$ N and $T_2 = 0$ N
(B) $T_1 = 0$ N and $T_2 = 100$ N
(C) $T_1 = 75$ N and $T_2 = 25$ N
(D) $T_1 = 25$ N and $T_2 = 75$ N

[Ans. B]

$W = T_1 + T_2$



$T_2\left(\frac{L}{2}\right) = w\left(\frac{L}{2}\right) \Rightarrow T_2 = w = 100\text{ N}$

$\Rightarrow T_1 = 0, T_2 = 100\text{ N}$

12. The time series forecasting method that gives equal weightage to each of the m most recent observations is_________
(A) Moving average method
(B) Exponential smoothing with linear trend
(C) Triple exponential smoothing
(D) Kalman Filter

[Ans. A]*

It gives equal weight to the previous data for a fixed period

13. An ideal gas undergoes a process from state $1(T_1 = 300\text{ k}, p_1 = 100\text{kPa})$ to state $2(T_2 = 600\text{ k}, p_2 = 500\text{ kPa})$. The specific heats of the ideal gas are: C_p= 1kJ/kg-k and $C_v = 0.7$ kJ/kg-k. The change in specific entropy of the ideal gas from state 1 to state 2 (in kJ/kg-k)________ (correct to two decimal places).

[Ans. *] Range: 0.20 to 0.22

$$\Delta S = C_p \ln\left(\frac{T_2}{T_1}\right) + (C_u - C_p)\ln\left(\frac{p_2}{p_1}\right)$$

$$\Rightarrow \Delta S = 1 \times \ln\left(\frac{600}{300}\right) + (0.7 - 1)\ln\left(\frac{500}{100}\right)$$

$$\Rightarrow \Delta S = \ln 2 + (-0.3)\ln 5 = ln2 - (0.3)ln5$$

$$\Rightarrow \Delta S = 0.21031$$

14. For a Pelton wheel with a given water jet velocity, the maximum output power from the Pelton wheel is obtained when the ratio of the bucket speed to the water jet speed is ________ (correct to two decimal places)

[Ans. *] Range: 0.48 to 0.52

For a Pelton wheel

$P = \dot{m}\,(v - u)u$

$\dot{E} = \frac{1}{2}\,\dot{m}v^2$

$\Rightarrow n = \frac{P}{E}$

$= \frac{(v - u)u}{v^2}$

$\Rightarrow \frac{dx}{du} = \frac{(v - 2u)}{v^2}$

for n_{max}

$\frac{dx}{du} = 0$

$\Rightarrow v = 2u$

$\text{i. e} \frac{u}{v} = \frac{1}{2} = 0.5$

15. The rank of the matrix $\begin{bmatrix} -4 & 1 & -1 \\ -1 & -1 & -1 \\ 7 & -3 & 1 \end{bmatrix}$ is

(A) 1 (B) 2
(C) 3 (D) 4

[Ans. B]

$\begin{bmatrix} -4 & 1 & -1 \\ -1 & -1 & -1 \\ 7 & -3 & 1 \end{bmatrix}$

$= 0$

$(A) = 0, \qquad \rho(A) \le 2$

Take number of older '2'

$\begin{bmatrix} -1 & -1 \\ -3 & 1 \end{bmatrix} = -1 - 3 = -4 \ne 0$

If at least one minor of older (2) is not equal to zero, and minor of order greater than '2' equal to zero, Then we can say that Rank is "2"

C (A)= 2

16. If σ_1 and σ_3 are the algebraically largest and smallest principal stresses respectively, the value of the maximum shear stress is_________ .

(A) $\frac{\sigma_1+\sigma_3}{2}$ (B) $\left(\frac{\sigma_1-\sigma_3}{2}\right)$
(C) $\left(\frac{\sigma_1+\sigma_3}{2}\right)$ (D) $\sqrt{\frac{\sigma_1-\sigma_3}{2}}$

[Ans. B]*

maximum shear stress $\frac{\sigma_1 - \sigma_3}{2}$

17. The number of atoms per unit cell and the number of slip systems, respectively, for a face centered cubic (FCC) crystal are?

(A) 3, 3 (B) 3, 12

(C) 4, 12 (D) 4, 48

[Ans. C]*

Unit cell	N	CN	a/R	APF
Simple cubic	1	6	2	0.52
Body centered cubic	2	8	$4/\sqrt{3}$	0.68
Face centered cubic	4	12	$4/\sqrt{2}$	0.74
Hexagonal close packed	6	12	$a/R = 2$ $c/a = 1.633$	0.74

18. The equation of motion for a spring-mass system excited by a harmonic force is $M\ddot{x} + Kx = F\cos(\omega t)$, where M is the mass, K is the spring stiffness, F is the force amplitude and ω is the angular frequency of excitation. Resonance occurs when ω is equal to

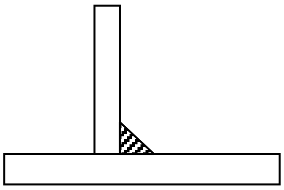
(A) $\sqrt{\frac{M}{K}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{K}{M}}$

(C) $2\pi\sqrt{\frac{K}{M}}$ (D) $\sqrt{\frac{K}{M}}$

[Ans. D]

Resonance occurs when force frequency equals to natural frequency.

19. The type of weld represented by the shaded region in the figure is



(A) Groove (B) Spot

(C) Fillet (D) Plug

[Ans. C]

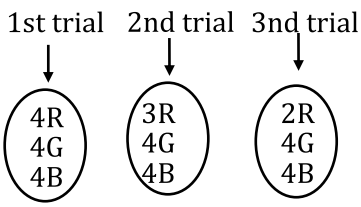
The shape of the welded region is fillet. Hence, it's a fillet joint

20. Four red balls, four green balls and four blue balls are put in a box. Three balls are pulled out of the box at random one after another without replacement. The probability that all the three balls are red is?

(A) $\frac{1}{72}$ (B) $\frac{1}{55}$

(C) $\frac{1}{36}$ (D) $\frac{1}{27}$

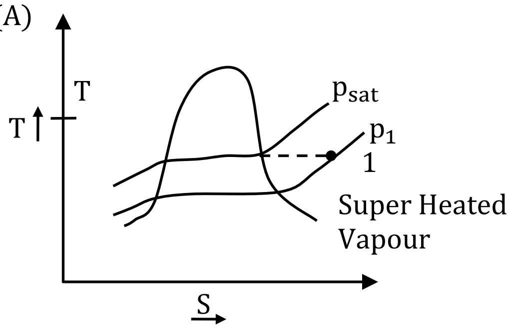
[Ans. B]



$$P\ (\text{All '3' balls are Red}) = \frac{4}{12}\times\frac{3}{11}\times\frac{2}{10}$$
$$= \frac{1}{55}$$

21. Which one of the following statements is correct for a super-heated vapour?
    (A) Its pressure is less than saturation pressure for a given temperature.
    (B) Its temperature is less than the saturation temperature for given pressure.
    (C) Its volume is less than volume of saturated vapour at given temperature.
    (D) Its enthalpy is less than he enthalpy of saturated vapour for a given pressure.
    [Ans. A]

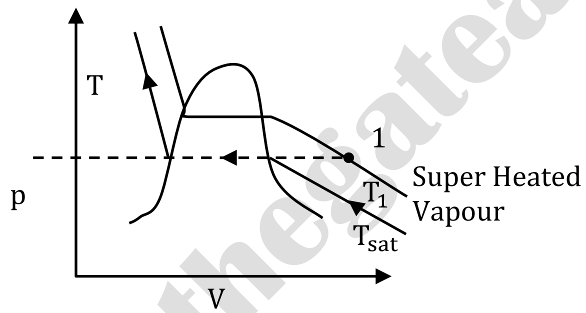
(A)



$p_1 < p_{sat}$

Here statement (A) is correct.

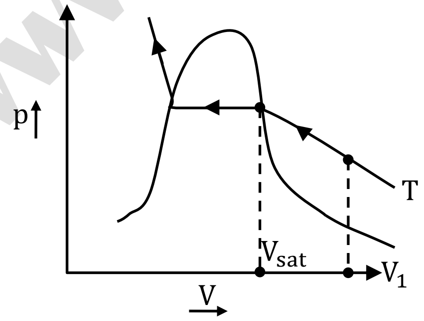
(B)



$T_1 > T_{sat}$

Here statement (B)is incorrect

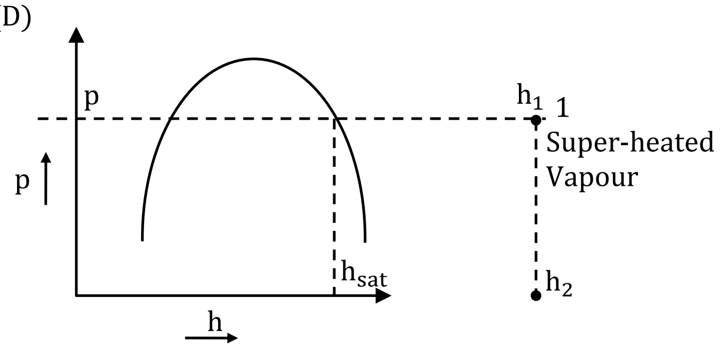
(C)



$\Rightarrow V_1 > V_{sat}$

Here statement (C)is incorrect.

(D)



$\Rightarrow h_1 > h_{sat}$

Here statement (D) is also incorrect.

Therefore answer is option (A).

22. A six faced fair dice is rolled five times. The probability (in %) of obtaining 'ONE' at least four times is

(A) 33.3 (B) 3.33

(C) 0.33 (D) 0.0033

[Ans. C]

Let "X=V" is probabililty of getting "1", "r" times out of 'n' trails

$n = 5, P = \frac{1}{6}, 2 = \frac{5}{6}$

$P(X \geq U) = P(X = 4) + P(X = 5)$

$5_{C_4} = \left(\frac{1}{6}\right)^4 \left(\frac{5}{6}\right) + 5_{C_5}\left(\frac{1}{6}\right)^5$

$= \frac{26}{6^5} = 0.0033$

Percentage probabililty $= 0.0033 \times 100 = 0.33$

23. Interpolator in a CNC machine

(A) Controls spindle speed (B) Co-ordinates axes movements

(C) Operates too changer (D) Commands canned cycle

[Ans. B]

To compute individual ratio velocity to drive the tool along the programmed path at given feed rate. If generated intermediate coordinate positions along the programmed path

24. For an Oldham coupling used between two shafts, which among the following statements are correct?

I. Torsional load is transferred along shaft axis.

II. A velocity ratio of 1:2 between shafts is obtained without using gears.

III. Bending load is transferred transverse to shaft axis.

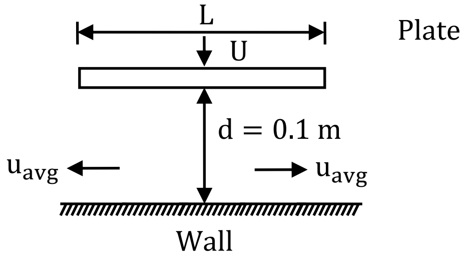
IV. Rotation is transferred along shaft axis.

(A) I and III (B) I and IV

(C) II and III (D) II and IV

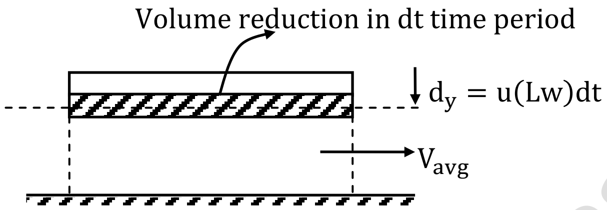
[Ans. B]

25. A flat plate of width L = 1 m is pushed down with a velocity U = 0.01 m/s towards a wall resulting in the drainage of the fluid between the plate and the wall as shown in the figure. Assume two-dimensional incompressible flow and that the plate remains parallel to the wall. The average velocity, u_{avg} of the fluid (in m/s) draining out at the instant shown in the figure is _________ (correct to three decimal places).



[Ans. *] Range: 0.045 to 0.055

dV = Volume reduction of fluid intraplexed between plate and wall in small time period dt → 0



$\Rightarrow dv = u\,(L_w)dt$

But $dv = 2 \times U_{avg}(hw)dt$

$\Rightarrow u(Lw)dt = 2\,U_{avg}\,hw\,dt$

$\Rightarrow U_{avg} = \dfrac{uL}{\partial h}$

$= \dfrac{0.01 \times 1}{2 \times 0.1} = 0.05\text{m /sec}$

Q.26 - Q.55 Carry Two Mark each.

26. A bar is compressed to half of its original length. The magnitude of true strain produced in the deformed bar is_________ (correct to three decimal places).

[Ans. *] Range: 0.69 to 0.70

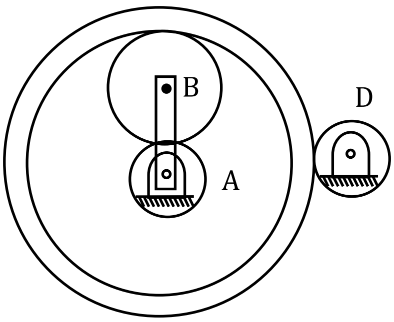
$L_o = L$

$L_1 = \dfrac{L}{2}$

$e = \ln\left(\dfrac{L_1}{L_o}\right) = -\ln(2) = -0.693$

magnitude is 0.693

27. An epicyclic gear train is shown in the figure below. The number of teeth on the gears A, B and D are 20, 30 and 20 respectively. Gear C has 80 teeth on the inner surface and 100 teeth on the outer surface. If the carrier arm AB is fixed and the sun gear A rotates at 300 rpm in the clockwise direction, then the rpm of D in the clockwise direction is



(A) 240 (B) −240
(C) 375 (D) −375

[Ans. C]

$T_A = 20$

$T_B = 30$

$T_D = 20$

$(T_C)_I = 80$

$(T_C)_{outer} = 100$

$W_{\frac{A}{B}} = 0 = W_{arm} = 0$

$W_A = +300$

$W_D = ?$

$$\frac{W_A - W_{arm}}{W_B - W_{arm}} = -\frac{T_B}{T_A} \Rightarrow \frac{W_A}{W_B} = -\frac{T_B}{T_A} \ldots\ldots (1)$$

$$\frac{W_B - W_{arm}}{W_C - W_{arm}} = +\frac{T_C}{T_B} \Rightarrow \frac{W_B}{W_C} = \frac{(T_C)_I}{T_A} \ldots\ldots (2)$$

$$\frac{W_C}{W_D} = -\frac{T_D}{T_C} \Rightarrow \frac{W_C}{W_D} = \frac{-T_D}{(T_C)_O} \ldots\ldots (3)$$

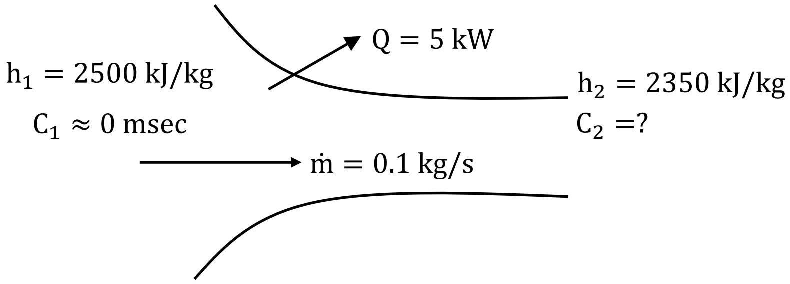
$$\frac{T_B (T_C)_I T_D}{T_A T_B (T_C)_O}$$

$$\frac{W_A}{W_D} = \frac{T_D}{T_A} \times \frac{(T_C)_I}{(T_C)_0}$$

$$W_D = W_A \left[\frac{T_A}{T_D}\right]\left(\frac{[T_C/0]}{[T_C/I]}\right)$$

$$W_D = 300\left[\frac{20 \times 100}{80 \times 20}\right] = +375 = 375 \text{ clockwise}$$

28. Steam flows through a nozzle at a mass flow rate of $\dot{m} = 0.1$ kg/s with a heat loss of 5 kW. The enthalpies at inlet and exit are 2500 kJ/kg and 2350 kJ/kg, respectively. Assuming negligible velocity at inlet ($C_1 \approx 0$), the velocity (C_2) of steam (in m/s) at the nozzle exit is _________ (correct to two decimal places).



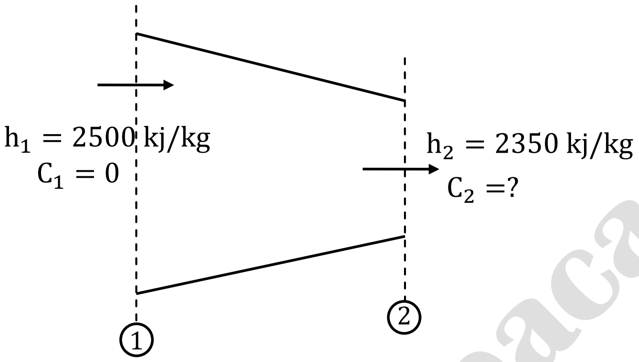
[Ans. *] Range: 445 to 450

$\dot{m} = 0.1\dfrac{\text{kg}}{\text{s}}\dot{Q} = 5\text{kW(heat loss)}$

Applying SFEE

$\dot{m}\left(h_1 + \dfrac{1}{2}c_1^2 + gz_1\right) + \dot{Q} = \dot{m}\left[h_2 + \dfrac{1}{2}c_2^2 + gz_2\right] + \dot{W}_{cv}$

$c_1 = 0$ and $\dot{W}_{cv} = 0$



$z_1 = z_2$(assume)

$\dot{m}h_1 + \dot{Q} = \dot{m}h_2 + \dot{m}\dfrac{1}{2}c_2^2$

$\Rightarrow \dot{m} \times \dfrac{1}{2}c_2^2 = \dot{m}(h_1 - h_2) + \dot{Q}$

$\Rightarrow 0.1 \times \dfrac{1}{2}c_2^2 \times 10^{-3} = 0.1(2500 - 2350) - 5$

$c_2 = 447.213$ m/s

29. The maximum reduction in cross-sectional area per pass (R) of a cold wire drawing process is $R = 1 - e^{-(n+1)}$, where n represents the strain hardening co-efficient. For the case of a perfectly plastic material, R is?

(A) 0.865 (B) 0.826
(C) 0.777 (D) 0.632

[Ans. D]

For ideal case

$\sigma_d = y_f \ln\left(\dfrac{A_0}{A_1}\right)$

For maximum reduction

$\sigma_d = y_{f'} \ln\dfrac{A_o}{A_f} = 1$

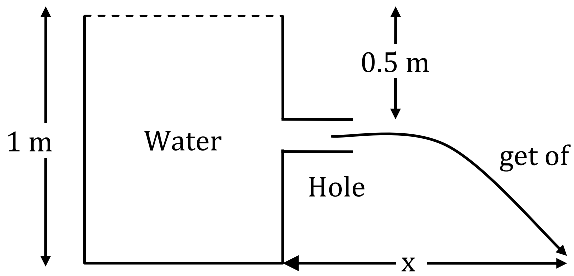
% reduction

$\frac{A_o - A_f}{A_o} \quad \frac{A_o}{A_f} = e \;\theta$

$= 1 - \frac{1}{e} = 63.2\%$

$= 0.63$

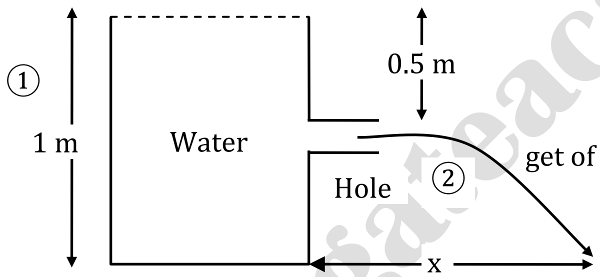
30. A tank open at the top with a water level of 1 m, as shown in the figure, has a hole at a height of 0.5 m. A free jet leaves horizontally from the smooth hole. The distance X (in m) where the jet strikes the floor is ________



Container

(A) 0.5
(B) 1.0
(C) 2.0
(D) 4.0

[Ans. B]



Container

Applying Bernoulli's equation between section ① and section ② for the given time instant

$$\frac{P_1}{\rho_g} + \frac{V_1^2}{2g} + y_1 = \frac{P_2}{\rho_g} + \frac{V_2^2}{2g} + y_2$$

But $y_1 = y_2$

$$\Rightarrow \frac{P_1}{\rho_g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho_g} + \frac{V_2^2}{2g}$$

By continuity equation

$A_1V_1 = A_2V_2$

But for $A_1 \gg A_2$

$V_2 \gg V_1$

$\Rightarrow V_1^2 \to 0$ as compared to V_2^2

$$\Rightarrow \frac{P_1 - P_2}{\rho_g} = \frac{V_2^2}{2g}$$

$\Rightarrow V_2 = \left[2\left(\frac{P_1 - P_2}{\rho}\right)\right]^{1/2}$

But $P_1 = P_{atm} + \rho_g \times h$. Where $h = 0.5$

$P_2 = P_{atm}$

$\Rightarrow P_1 - P_2 = \rho_g h$

Hence $V_2 = \sqrt{2gh}$.

Time taken by the get to cover horizontal distance x is same as time taken by it to cover vertical distance of $h = 0.5$ m

$\Rightarrow t = \sqrt{\frac{2h'}{g}}$

Because initial velocity of efflux of get is purely horizontal

$\Rightarrow x = V_2 t$

$= \sqrt{2gh} \times \sqrt{\frac{2h'}{g}} = 2 \times 0.5 = 1\text{m}$

31. Let x_1, x_2 be two independent normal random variables with means μ_1, μ_2 and standard deviation σ_1, σ_2,respectively. Consider $y = x_1 - x_2; \mu_1 = \mu_2 = 1, \sigma_1 = 1, \sigma_2 = 2$. Then,
(A) Y is normally distributed with mean 0 and variance 1.
(B) Y is normally distributed with mean 0 and variance 5.
(C) Y has mean 0 and variance 5, but is NOT normally distributed.
(D) Y has mean 0 and variance 1, but is NOT normally distributed.

[Ans. B]

Mean of R.V 'Y'$=\in [Y] = \in [X_1 - X_2] = \in [X_1] - \in [X_2]$

$= \mu_1 - \mu_2 = 1 - 1 = 0$

Mean E(y)] = 0

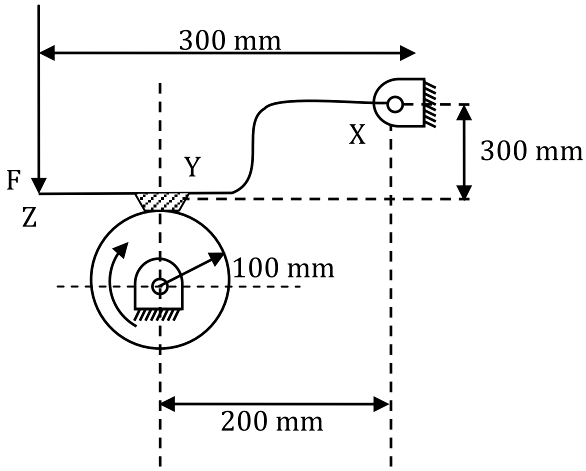
Variance of Y, U(Y)= $V(X_1 - X_2) = V(X_1) + V(X_2) - 2\text{cov}(X,Y)$

[Given X_1, X_2 an independent so cov (X, Y)= 0']

$= U(x_1) + U(x_2) - 2(0) = \sigma_1^2 + \sigma_2^2$

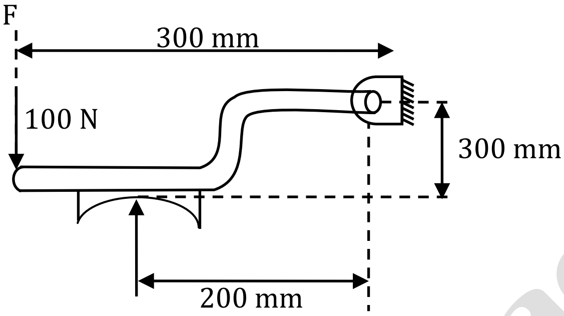
$1^2 + 2^2 = 5$

32. The schematic of an external drum rotating clockwise engaging with a short shoe is shown in the figure. The shoe is mounted at point Y on a rigid lever XYZ hinged at point X. A force F = 100 N is applied at the free end of the lever as shown. Given that the coefficient of friction between the shoe and the drum is 0.3 the braking torque (in Nm) applied on the drum is _____ (correct to two decimal places).



[Ans. *]Range: 8.00 to 9.00

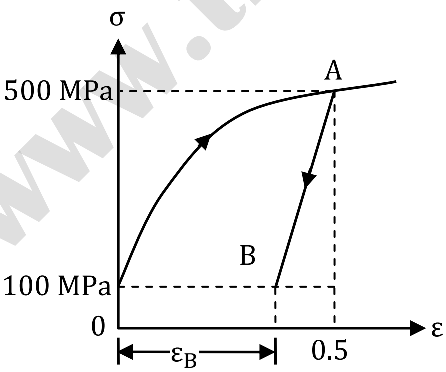
$F(0.3) - N(0.2) + \mu N(0.3) = 0$



Braking torque $= \mu NR$

$= 8.13$ Nm

33. The true stress (σ) - true strain (ϵ) diagram of a strain hardening material is shown in figure. First, there is loading up to point A, i.e., up to stress of 500 MPa and strain of 0.5. Then from point A, there is unloading up to point B, i.e. to stress of 100 MPa. Given that the Young's modulus E = 200 GPa, the natural strain at point B(ϵ_B) is _____ (correct to three decimal places).



[Ans. *] Range: 0.498 to 0.498

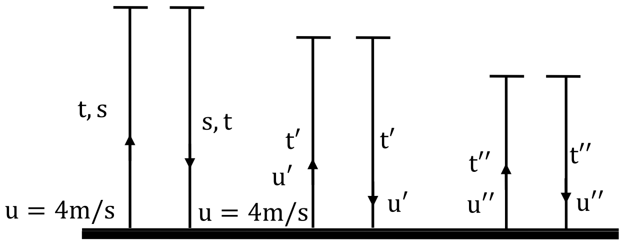
$$\frac{(500 - 100) \times 10^6}{(0.5) - \epsilon} = 200 \times 10^9$$

$\epsilon = 0.498$

34. A point mass is shot vertically up from ground level with a velocity of 4 m/s at time, t = 0. It loses 20% of its impact velocity after each collision with the ground. Assuming that the acceleration due to gravity is 10 m/s^2 and that air resistance is negligible, the mass stops bouncing and comes to complete rest on the ground after a total time (in seconds) of

(A) 1
(B) 2
(C) 4
(D) ∞

[Ans. C]*



(1) → t=?

$V = u + at$

$0 = 4 - 10t$

$t = \frac{4}{10} = 0.4s$

(2) → t′=?

$u' = 0.8 \times u$

$= 0.8 \times 4 = 3.2 \text{ m/s}$

$v' = u' + at'$

$0 = 3.2 - 10t'$

$t' = \frac{3.2}{10} = 0.32s$

(3) → t″ =?

$u'' = 0.8\, u'$

$= 0.8 \times 3.2 = 2.56 \text{ m/s}$

$V'' = u'' + at''$

$0 = 2.56 - 10t''$

$t'' = 0.256s$

So, t, t,″ t″ are forming GP series

So total time $= 2(t + t' + t'' + \cdots 0)$

$= 2[0.4 + 0.32 + 0.256 + \cdots 0]$

$= 2 \times \frac{0.4}{1 - 0.8} = 2 \times 2 = 4s$

35. The value of the integral $\oiint_S \vec{r}.\vec{n}\, dS$ over the closed surface S bounding a volume V,$\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$ is the position vector and $\vec{n}$ is the normal to the surface S ,is

(A) V
(B) 2V
(C) 3V
(D) 4V

[Ans. C]

$$\oiint \vec{r}\ \vec{n}\ dV = \iiint_V (\nabla.\vec{r})\ dV$$

$$(\nabla.\vec{r}) = \left(\frac{i\,\partial}{\partial x} + \frac{j\,\partial}{\partial y} + \frac{k\,\partial}{\partial z}\right) \odot (x\hat{i} + y\hat{j} + z\hat{k})$$

$$= 1 + 1 + 1 = 3$$

$$\oiint \vec{r}.\vec{n} = \iiint_V (3)\ dV$$

$$= 3 \underbrace{\iiint_v}\ dv\ 'V'\ \text{volume of surface}$$

$$= 3V$$

36. As self-aligning ball bearing has a basic dynamic load rating (C_{10}, for 10^6 revolutions) of 35 kN. If the equivalent radial load on the bearing is 45 kN, the expected life (in 10^6 revolutions) is

(A) Below 0.5
(B) 0.5 to 0.8
(C) 0.8 to 1.0
(D) Above 1.0

[Ans. A]

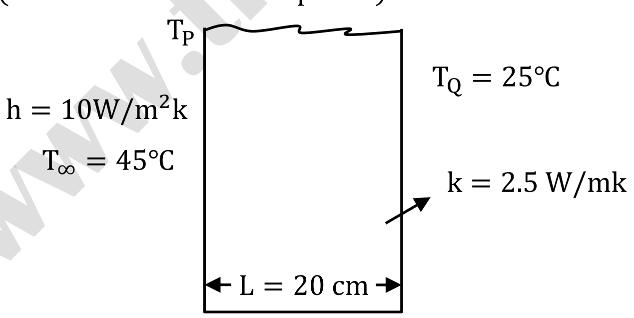
Given c = 35 kN

P = 45kN

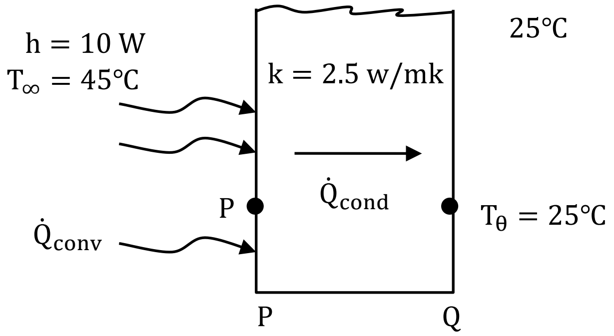
$$L_{10} = \left(\frac{C}{P}\right)^3$$

$$= 0.47$$

37. A plane slab of thickness L and thermal conductivity k is heated with a fluid on one side (P) and the other side (Q) is maintained at a constant temperature, (T_Q) of 25°C, as shown in the figure. The fluid is at 45°C and the surface heat transfer coefficient, h, is 10 W/m^{2}K. The steady state temperature, TP, (in °C) of the side which is exposed to the fluid is _____ (correct to two decimal places)



[Ans.*] Range: 33.50 to 34.30



$\dot{Q}_{conv} = \dot{Q}_{cond}$ by condition of steady state

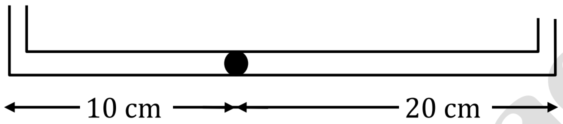
$$\Rightarrow hA(T_\infty - T_P) = \frac{kA}{L}(T_P - T_Q)$$

$$\Rightarrow \frac{hL}{h}(T_\infty - T_P) = T_P - T_Q$$

$$\Rightarrow \frac{10 \times 0.2}{2.5}(45 - T_P) = T_P - 25$$

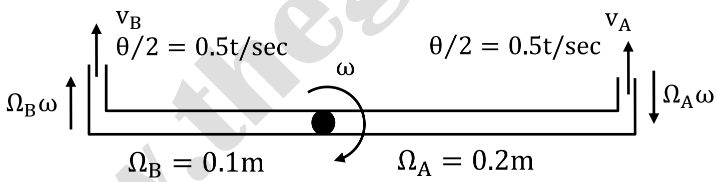
$$\Rightarrow T_P = 33.88°C$$

38. A sprinkler shown in the figure rotates about its hinge point in a horizontal plane due to water flow discharged through its two exit nozzles.



The total flow rate Q through the sprinkler is 1 liter/see and the cross-sectional area of each exit nozzle is $1cm^2$. Assuming equal flow rate through arms and a frictionless hinge, the steady state angular speed of the rotation (in rad/s) of the sprinkler is ________ (correct to two decimal places).

[Ans. *] Range: 9.50 to 10.50



Relative velocities of water with sprinkler

$$V_A = \frac{\theta/2}{A} = \frac{1 \times 10^{-3}}{2 \times 10^{-4}} = 5m/sec$$

$U_B = 5m/sec$

Absolute velocity from B side

$V'_{abs} = (+r_B\omega) = V_B$

$V'_{abs} = V_B + \Omega_B\,\omega$

$= 5 + 0.1\omega$

Absolute velocity from A side

$V_{abs} = (-\Omega_A\omega) = V_A$

$V_{abs} = V_A - \Omega_A\omega$

$V_{abs} = 5 - 0.2\omega$

The external torque to the sprinkler is zero

$\Rightarrow \sum T = 0$

$\Rightarrow \dot{m}_A V_{abs}\Omega_A - \dot{m}_B V'_{abs}\,\Omega_B = 0$

$\Rightarrow \rho\left(\frac{\theta}{2}\right)(5 - 0.2\omega)0.2 - \rho\left(\frac{\theta}{2}\right)(5 + 0.1\,\omega)0.1 = 0$

$\Rightarrow 1 - 0.04\omega - 0.5 - 0.01\omega = 0$

$\Rightarrow \omega = 10$ rad/sec

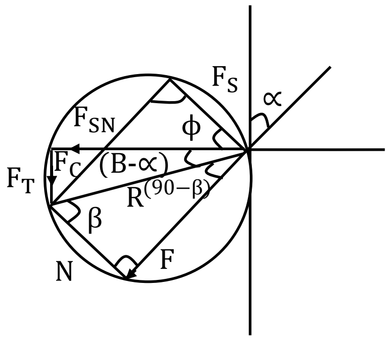
39. An orthogonal cutting operation is being carried out in which uncut thickness is 0.010 mm, cutting speed is 130 m/min, rake angle is 15° and width of cut is 6 mm. It is observed that the chip thickness is 0.015 mm, the cutting force is 60 N and the thrust force is 25 N. The ratio of friction energy to total energy is _____ (correct to two decimal places).

[Ans.*] Range: 0.39 to 0.49

$T_1 = 0.01$ mm

$V_c = 130$ m/min

$\propto = 15°$



$\tan(\beta - \alpha) = \frac{F_T}{F_C} = \frac{25}{60} = 0.4167$

$\beta - \propto = 22.619$

$\beta = 37.62$

$\sin\beta = \frac{F}{R}$

$F = R\sin\beta = \sqrt{60^2 + 25^2}\,\text{Sin}\,\beta$

$F = 39.677$ N

$= \frac{39.67}{60} \times \frac{0.01}{0.015}$

$= 0.44$

40. In a Lagrangian system, the position of a fluid particle in a flow is described as $x = x_0 e^{-kt}$ and $y = y_0 e^{kt}$ where t is the time while x_0, y_0 and k are constants. The flow is

(A) Unsteady and one-dimensional
(B) Steady and two-dimensional
(C) Steady and one-dimensional
(D) Unsteady and two-dimensional

[Ans. B]

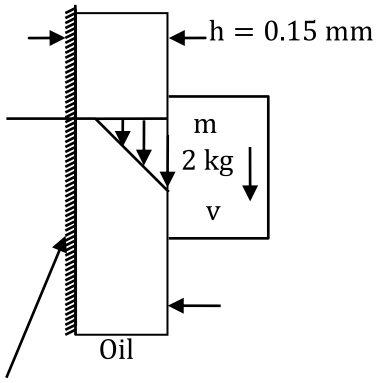
$x = x_0\, e^{-bt}$

$y = y_0 e^{bt}$

$\Rightarrow u = \frac{dx}{dt} = x_0\, e^{-bt} \times (-b)$
$= -bx$
and $v = \frac{dy}{dt} = y_0 e^{bt} \times (b)$
$= yb$
i.e. $\vec{V} = u\hat{i} + v\hat{j}$
$= -bx\,\hat{i} + yb\hat{j}$
$\vec{V}$, Now represents eulerian description of flow, i.e. velocity vector at (x, y) for time instant t.
$\Rightarrow \frac{\partial \vec{V}}{\partial x} \neq 0, \frac{\partial \vec{V}}{\partial y} \neq 0$ hence flow is 2D
Also $\frac{\partial \vec{V}}{\partial t} = 0$ therefore flow is steady
Thus flow is steady two dimensional

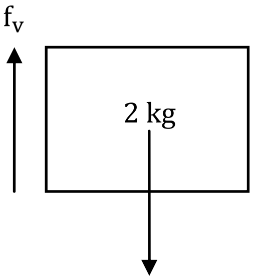
41. An explicit forward Euler method is used to numerically integrate the differential equation $\frac{dy}{dt} = y$ using a time step of 0.1. With the initial condition y (0) = 1, the value of y(1) computed by this method is ____ (correct to two decimal places).
[Ans. *]Range: 2.55 to 2.65
$\frac{dy}{dt} = y$
$h = 0.1$
$y(0) = 1$
$x_0 = 0, y_0 = 1$
$y(1)$
$y_{i+1} = y_i + h\, f(xi, yi)$
h=0.1
$x_1 = 0.1, \Rightarrow y_1 = y_0 + h\, y_0 = (1 + h)y_0$
$x_2 = 0.2 \Rightarrow y_2 = y_1 + hy_1 = (1 + h)^2\, y_0$
⋮
$x_{10} = 1 \Rightarrow y_{10} = y(1) = (1 + h)^{10} y_0$
$= (1.1)^{10} y_0$
$= 2.593$

42. A solid block of 2.0 kg mass slides steadily at a velocity V along a vertical wall as shown in the figure below. A thin oil film of thickness h = 0.15 mm provides lubrication between the block and the wall. The surface area of the face of the block in contact with the oil film is 0.04 m^2. The velocity distribution within the oil film gap is linear as shown in the figure. Take dynamic viscosity of oil as 7×10^3 Pa-s and acceleration due to gravity as 10 m/s^2. Neglect weight of the oil. The terminal velocity V (in m/s) of the block is ____(correct to one decimal place).



[Ans. *] Range: 10.6 to 10.8

Based on the situation predicted in the problem the FDD of the body can be drawn as



As the body is moving with terminal velocity, this means the resultant of all forces on the block is zero

$\Rightarrow f_v = w$

Where f_v is the viscous force on the block by oil

$\Rightarrow f_v = mg$

$\Rightarrow T_w|_{y=h} A = mg$

$$\Rightarrow \mu \left.\frac{du}{dy}\right|_{y=h} = \frac{mg}{A}$$

But as the velocity profile in the oil is linear

$$\Rightarrow \left.\frac{du}{dy}\right|_{y=h} = \frac{V}{h}$$

$$\Rightarrow \mu\frac{V}{h} = \frac{mg}{A}$$

$$\Rightarrow V = \frac{mgh}{\mu A}$$

$$\Rightarrow V = \frac{2 \times 9.81 \times 0.15 \times 10^{-3}}{7 \times 10^{-3} \times 0.04} = 10.5 \text{ m/sec}$$

43. An electrochemical machining (ECM) is to be used to cut a through hole into a 12 mm thick aluminum plate. The hole has a rectangular cross-section, 10 mm × 30 mm. The ECM operation will be accomplished in 2 minutes, with efficiency of 90%. Assuming specific removal rate for aluminum as 3.44×10^2 mm^3/(As), the current (in A) required is ____ (correct to two decimal places).

[Ans. *]Range: 968.80 to 969.20

Specific remoual rate $= 3.44 \times 10^{-2}\ \text{mm}^3/\text{As}$

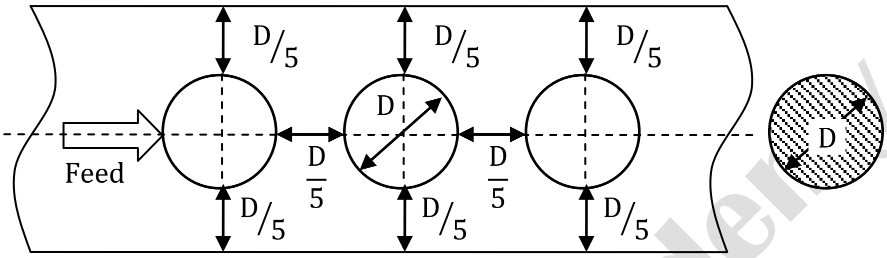
Volume of metal removed $= 30 \times 10 \times 12 = 3600\ \text{mm}^3$

$$\text{Energy required} = \frac{3600}{3.44 \times 10^{-2}} = 104651.16\ \text{As}$$

$$\eta = 0.9 \text{ actual energy required} = \frac{104657.16}{0.9} = 116279.06\ \text{As}$$

$$\text{Current} = \frac{116279.06}{120} = 968.994$$

44. The percentage scrap in a sheet metal blanking operation of a continuous strip of sheet metal as shown in the figure is ______ (correct to two decimal places)



[Ans. *] Range: 52.00 to 54.00

$$\%\ \text{Utilisation} = \frac{\text{Area utilised}}{\text{Total Area of the sheet}}$$

$$= \frac{\frac{\pi}{4}D^2}{\left[D + \frac{D}{5}\right]\left[D + 2\frac{D}{5}\right]}$$

$$= \frac{\frac{\pi}{4}D^2}{\left[\frac{6D}{5}\right]\left[\frac{7D}{5}\right]}$$

$$\%\ \text{Utilization} = \frac{25\pi}{(42)(4)} = 0.467 = 46.7$$

$$\%\ \text{Scrap} = 53.3\%$$

45. F(s) is the Laplace transform of the function

$f(t) = 2t^2e^{-t}$

F (1) is ________(Correct two decimal places)

[Ans. *] Range: 0.48 to 0.52

$$t^n \overset{L.T}{\leftrightarrow} \frac{n!}{S^{n+1}}$$

$$e^{-at}t^n \overset{L.T}{\leftrightarrow} \frac{n!}{(S+a)^{n+1}}$$

$$L(f(t)) = F(S)$$

$$L(2t^2e^{-t}) = 2.\frac{2!}{(S+1)^3}$$

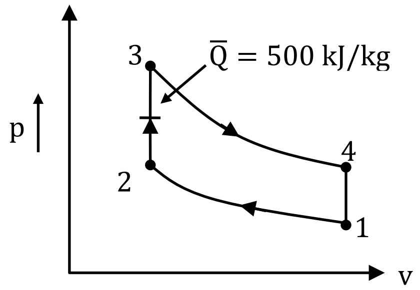
$$F(S) = \frac{4}{(S+1)^3}$$

$F(1) = \frac{4}{2^3} = 0.5$

46. An engine working on air standard Otto cycle is supplied with air at 0.1 MPa and 35°C. The compression ratio is 8. The heat supplied is 500 kJ/kg. Property data for air. $C_p = 1.005$ kJ/kg K, $C_v = 0.718$ kJ/kg K. R = 0.287 kJ/kg K. The maximum temperature (in K) of the cycle is ____ (correct to one decimal place).

[Ans. *] Range: 1403.0 to 1406.0

Based on the given condition the working cycle can be plotted as.



Given $T_1 = 35°C, p_1 = 0.1$ MPa.

Also $r = \frac{V_1}{V_2} = 8$

1→ 2is adiabatic compression process therefore,

$T_1 V_1^{r-1} = T_2 V_2^{r-1}$

$\Rightarrow T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{r-1}$

$\Rightarrow T_2 = T_1 \times (8)^{1.4-1}$

$= 308 \times 8^{0.4}$

$= 707.59$ K

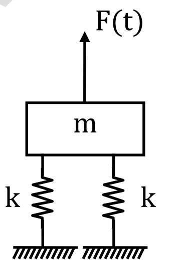
2→3 is a constant volume heat addition process therefore,

$Q_{2\to3} = \dot{m} C_v \Delta T$

$\Rightarrow 500 = 0.718 \times (T_3 - T_2)$

$\Rightarrow T_2 = \frac{500}{0.718} + 707.59 = 1403.9$

47. A machine of mass m = 200 kg is supported on two mounts, each of stiffness k = 10 kN/m. The machine is subjected to an external force (in N) F(t) = 50 cos 5t. Assuming only vertical translatory motion, the magnitude of the dynamic force (in N) transmitted from each mount to the ground is _______ (correct to two decimal places).



[Ans. *] Range: 33.00 to 33.50

M= 200 kg

$$\epsilon = \frac{\sqrt{1+(2\,\xi\,\frac{\omega}{\omega_n})^2}}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2+\left(2\,\xi\,\frac{\omega}{\omega_n}\right)^2}}$$

Given $\xi = 0$

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

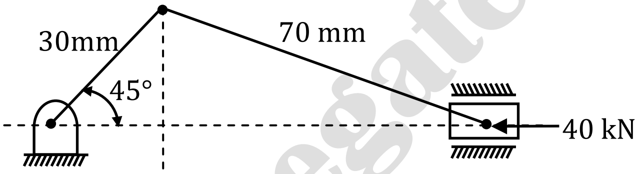
$$\omega = \sqrt{\frac{k_{eq}}{m}} = \sqrt{\frac{2\times10^3\times10}{200}} = 10$$

$$\epsilon = \frac{1}{1-\left(\frac{5}{10}\right)^2} = \frac{4}{3}$$

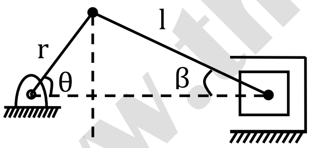
$$\epsilon = \frac{F_T}{F_O} = \frac{4}{3} = F_T = \left(\frac{4}{3}\right)(50) = 66.67\text{ kN}$$

For each spring= 33.33 kN

48. A slider crank mechanism is shown in the figure. At some instant, the crank angle is 45° and a force of 40 N is acting towards the left on the slider. The length of the crank is 30 mm and the connecting rod is 70 mm. Ignoring the effect of gravity, the magnitude of the crankshaft torque (in Nm) needed to keep the mechanism in equilibrium is ____ (correct to two decimal places).



[Ans. *] Range:1.00 to 1.20



$$l\sin\beta = r\sin\theta \Rightarrow \sin\beta = \frac{\sin\theta}{n}$$

$$\sin\beta = \frac{\sin 45}{\left(\frac{70}{30}\right)} \Rightarrow \beta = 17.64°C$$

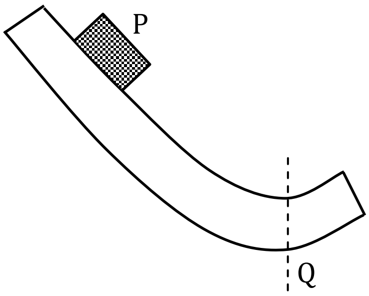
$F_c\cos\beta = 40$ kN

$F_c = 41.97$ kN

Crank Effort $(F_T)= F_c\sin(\beta+\theta) = 37.278$ kN

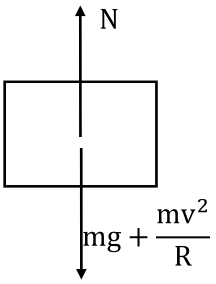
$T = (F_T)r = 1.118$ Nm

49. Block P of mass 2 kg slides down the surface and has a speed 20 m/s at the lowest point Q, where the local radius of curvature is 2 mass as shown in the figure. Assuming $g = 10\ m/s^2$, the normal force (in N) at Q is ______ (correct to two decimal places)



[Ans. *] Range: 419.00 to 421.00

At θ the free body diagram



$$N = mg + \frac{mv^2}{R}$$
$$= 420\ N$$

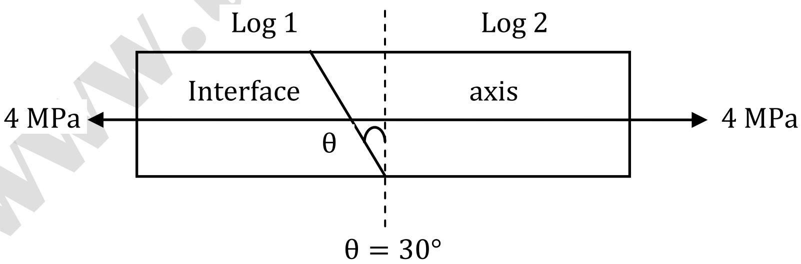
50. A carpenter glues a pair of cylindrical wooden logs by bonding their end faces at an angle of $\theta = 30°$ as shown in the figure

The glue used at the interface fails if

Criterion 1: The maximum normal stress exceeds 2.5 MPa.

Criterion 2: The maximum shear stress exceeds 1.5 MPa.

Assume that the interface fails before the logs fail. When a uniform tensile stress of 4 MPa is applied the interface



(A) Fails only because of criterion 1

(B) Fails only because of criterion 2

(C) Fails because of both criterion 1 and 2

(D) Does not fail

[Ans. C]*

Normal stress on inclined plane

$\sigma' = \sigma_x \cos^2 \theta$

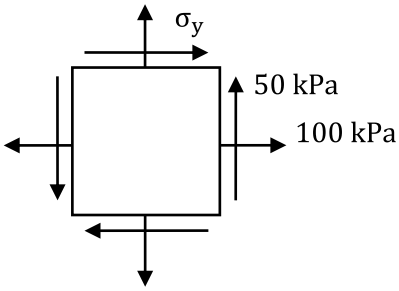
$= 4 \times \cos^2 30 = 3$ MPa

Shear stress on inclined plane $\tau' = \frac{\sigma_x}{2} \sin 2\theta$

$= 2 \times \sin 60° = 1.73$ MPa

Since both the stress exceeds the given limits,

51. The state of stress at a point, for a body in plane stress, is shown in the figure below. If the minimum principle stresses 10 kPa, normal stress σ_y (in kPa) is ________



(A) 9.45 (B) 18.88
(C) 37.78 (D) 75.50

[Ans. C]

$\sigma_x = 100$

$\sigma_y = ?$

$\tau_{xy} = 50$

$\sigma_2 = 10$

$$\sigma_2 = \left(\frac{\sigma_x + \sigma_y}{2}\right) - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + (\tau_{xy})^2}$$

$\sigma_y = 37.78$ kPa

52. A tank of volume 0.05 m^3 contains a mixture of saturated water and saturated steam at 200° C. The mass of the liquid present is 8 kg. The entropy (in kJ/kg K) of the mixture is ______ (correct to two decimal places).

Property data for saturated steam and water are:

At 200°C, $p_{sat} = 1.5538$ MPa

$v_f = 0.001157\ m^3/kg$, $v_g = 0.12736\ m^3/kg$

$s_{fg} = 4.1014$ kJ/kg K, $s_f = 2.3309$ kJ/kg K

[Ans. *]Range: 2.45 to 2.55

$V_f = \dot{m}_f V_f$

$\Rightarrow = 8 \times 0.01157$

$\Rightarrow = 0.09256\ m^3$

$\Rightarrow V_g = V_g - V_f$

$\Rightarrow V_g = 0.5 - 0.09256$

$\Rightarrow V_g = 0.40744\ m^3$

Hence

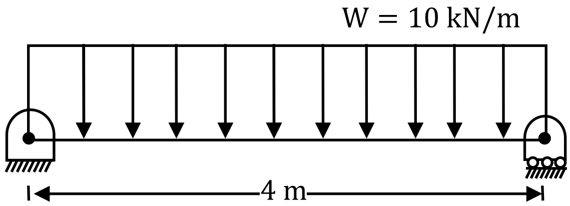
$$m_g = \frac{V_g}{v_g} = 3.199 \text{ kg}$$

$$\Rightarrow x = \frac{mg}{mg + m_f} = \frac{3.199}{8 + 3.199} = 0.0384$$

$$\Rightarrow S = S_f + x\, s_{fg}$$

$$= 2.488 \text{ kJ/kg} - \text{k}$$

53. A simply supported beam of width 100 mm, height 200 mm and length 4 m is carrying a uniformly distributed load of intensity 10 kN/m. The maximum bending stress (in MPa) in the beam is _____ (correct to one decimal place).



[Ans. *] Range: 29.8 to 30.1

$$M_{max} = \frac{qL^2}{8}$$

Hence $q = 10 \times 10^3$ N/m

$L = 4$ m

$$\frac{\sigma}{y} = \frac{M}{I}$$

$y = 0.1$ m

$$I = \frac{(0.1)(0.2)^3}{12} \text{ m}^4$$

$\Rightarrow \sigma = 30\text{MPa}$

54. The minimum value of $3x + 5y$ such that

$3x + 5y \le 15$

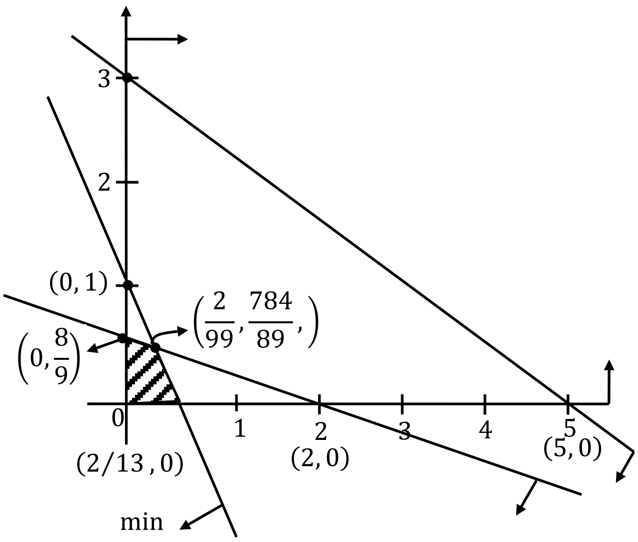
$4x + 9y \le 8$

$13x + 2y \le 2$

$x \ge 0, y \ge 0$

is _______.

[Ans. *] Range: 0 to 0



3x + 5y will be for x = 0 and y = 0

⇒ 3x + 5y reduce to zero

55. Processing times (including setup time) and due dates for six jobs, waiting to be processed at a work center are given in the table. The average tardiness (in days)using shortest processing time rule is _______(Correct to two decimal places)

Job	Processing(days)	Due date (days)
A	3	8
B	7	16
C	4	4
D	9	18
E	5	17
F	13	19

[Ans. *] Range: 6.31 to 6.35

By SPT rule,

J. b	P T	D D	Job flow time	Tardiness
A	3	8	0 + 3 = 3	0
C	4	4	3 + 4 = 7	3
E	5	17	7 + 5 = 12	0
B	7	16	12 + 7 = 19	3
B	9	18	19 + 9 = 28	10
F	13	19	28 + 13 = 41	22
			Total=	38

Total tardiness=38 Average tardiness per job= $\left(\frac{38}{6}\right) = 6.33$ day