PVP 23

Code: 23CE3201, 23ME3201

I B.Tech - II Semester – Regular / Supplementary Examinations
MAY 2025

ENGINEERING MECHANICS
(Common for CE, ME)

Duration: 3 hours Max. Marks: 70

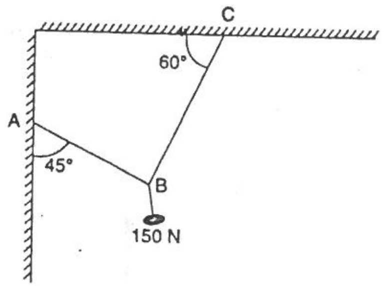
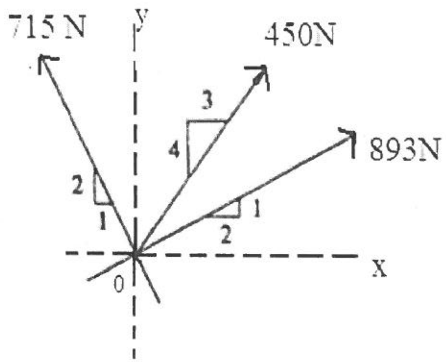
Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level CO – Course Outcome

PART – A

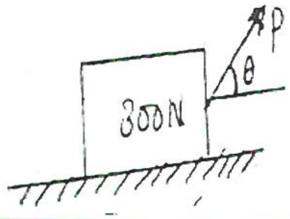
		BL	CO
1.a)	Define the term Free body diagram.	L2	CO1
1.b)	State parallelogram law of forces.	L2	CO1
1.c)	Illustrate different types of trusses.	L2	CO2
1.d)	Distinguish between Static and dynamic friction.	L2	CO2
1.e)	State parallel axis theorem.	L2	CO3
1.f)	Define centroid.	L2	CO3
1.g)	List out some examples of linear motion.	L2	CO4
1.h)	Define curvilinear motion.	L2	CO4
1.i)	Write the units of the following quantities: i) Angular velocity ii) Angular acceleration	L2	CO5
1.j)	State D'Alembert's principle for a particle.	L2	CO5

PART – B

<table>
<tr><th></th><th></th><th></th><th>BL</th><th>CO</th><th>Max. Marks</th></tr>
<tr><td colspan="6">UNIT-I</td></tr>
<tr><td>2</td><td>a)</td><td>State and explicate the Lami's theorem.</td><td>L2</td><td>CO1</td><td>4 M</td></tr>
<tr><td></td><td>b)</td><td>Compute the forces developed in the wires, supporting an electric fixture as shown in fig.

</td><td>L3</td><td>CO1</td><td>6 M</td></tr>
<tr><td colspan="6">OR</td></tr>
<tr><td>3</td><td>a)</td><td>Determine the resultant of three forces acting at point O as shown in figure.

</td><td>L3</td><td>CO1</td><td>6 M</td></tr>
<tr><td></td><td>b)</td><td>Distinguish coplanar and non-coplanar systems of forces with sketches.</td><td>L2</td><td>CO1</td><td>4 M</td></tr>
</table>

UNIT-II

4	a)	Describe and explicate about Angle of friction, Angle of repose.	L2	CO2	4 M
	b)	Determine the range of values 'θ' for which the force 'P' equal to 200N will move the 300N block resting on horizontal surface. μ = 0.8. refer Fig.	L3	CO2	6 M

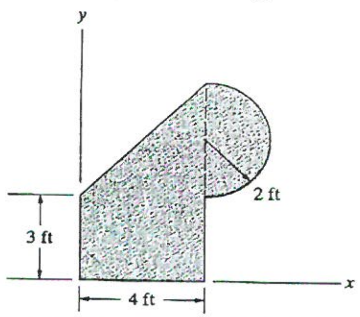


OR

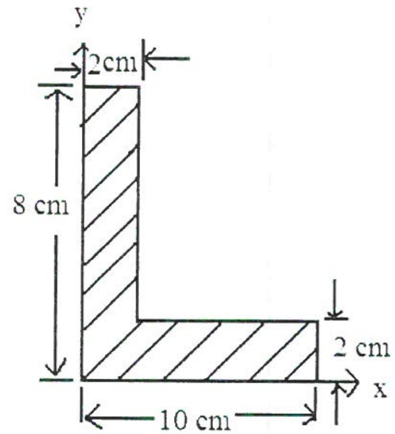
5	a)	List and brief out the laws of friction.	L2	CO2	4 M
	b)	The force required to pull a body of weight 200N on a rough horizontal plane is 100N. Determine the μ if the force is applied at an angle of 15^0 with the horizontal.	L3	CO2	6 M

UNIT-III

6	a)	Locate the coordinates of the centroid of the plane area shown in Fig.	L3	CO3	5 M

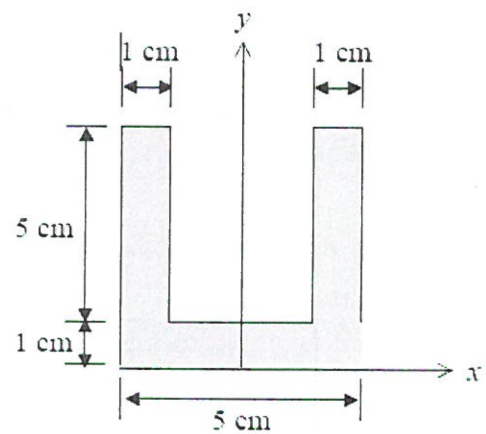


	b)	Determine the centroid of the area given below:	L3	CO3	5 M

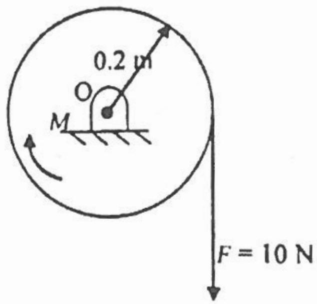


OR

7		Estimate the moment of inertia of the following plane figure with respect to the x and y axes.	L3	CO3	10 M



UNIT-IV					
8	a)	A stone is thrown vertically upwards with an initial speed of 30 m/s from the ground. Evaluate i) In what time it will reach the maximum height. ii) The greatest height reached by the stone above the ground level. iii) The velocity with which the stone strikes the ground iv) Total time it is in motion.	L3	CO4	5 M
	b)	Draw the motion curves of displacement - time, velocity - time, acceleration - time. Briefly explain.	L2	CO4	5 M
OR					
9	a)	A motorist is travelling at 80kmph,when he observes a traffic light 200 m ahead of him turns red. The traffic light is limited to stay red for 10 seconds. If the motorist wishes to pass the light without stopping, just as it turns to green, determine: (i) the required uniform deceleration of the motor, and (ii) the speed of the motor as it passes the light.	L3	CO4	5 M
	b)	A motor car attains its maximum speed of 80km/hr in a span of 1.2km. It continues at the speed for a distance of 1.8km and then a uniform retardation brings it to rest in 3 min. How far does the car travel and what is the total elapsed time.	L3	CO4	5 M

UNIT-V					
10	a)	A flywheel of diameter 50 cm starts from rest with constant angular acceleration 20 rad/s^2. Determine the tangential and the normal components of acceleration of a point on its rim 3 s after the motion began.	L3	CO5	5 M
	b)	A rotor decreases uniformly from rotating speed of 1800 rpm to rest in 320 s. Determine its angular deceleration and the number of radians rotated before coming to rest.	L3	CO5	5 M
OR					
11		The 30 kg disc shown in figure, is pin supported at its center. The disc is at rest. A constant moment M of 5 N-m is applied to the disc and a constant force F of 10 N is applied at the end of a rope wrapped on the disc. Determine the number of revolutions made by the disc when its angular velocity becomes 20 rad/s. 	L3	CO5	10 M

Engineering Mechanics (23CE3201, 23ME3201)
Scheme of Evaluation

1. a) Definition of Free Body diagram - 2M
   b) statement of parallelogram law/diagram/equation - 2M
   c) Any two types of trusses - 2M
   d) static friction - 1M ; Dynamic friction - 1M
   e) parallel axis theorem statement/equation - 2M
   f) definition of centroid - 2M
   g) Any two examples of linear motion - 2M
   h) definition of curvilinear motion/diagramatic representation - 2M
   i) units of angular velocity - 1M ; angular acceleration - 1M
   j) Statement of D'Alembert's principle/equation - 2M

2. a) Statement of Lami's theorem - 2M
   diagram and equation - 2M
   b) Given data - 2M
   Applying equilibrium conditions - 2M
   Find tensions - 2M

3. a) Given data - 2M
   Find angles - 2M
   resultant and its direction - 2M
   b) Coplanar system of forces - 2M
   Non-coplanar system of forces - 2M

4. a) Definition of angle of friction - 2M
   Definition of angle of repose - 2M
   b) Given data - 2M
   Free body diagram - 2M
   Find range of values of θ - 2M

5. a) Any 4 laws of friction - 4M

b) Given data - 2M
Free body diagram - 2M
Find 'N' and 'μ' - 2M

6. a) Divide composite area into known shapes - 2M
Find centroids of individual areas - 2M
Find centroid of composite area - 1M

b) Divide composite area into known shapes - 2M
Find centroids of individual areas - 2M
Find centroid of composite area - 1M

7. Divide the composite area into known shapes - 3M
Find Moment of inertia of individual areas - 4M
Find Moment of inertia of composite area w.r.t x & y axes - 3M

8.
a) Given data - 2M
Kinematic equations - 1M
Find Motion parameters - 2M

b) Motion curves of displacement w.r.t. time - 2M
Motion curves of velocity w.r.t time - 2M
Motion curves of acceleration w.r.t time - 1M

9. a) Given data - 2M
Kinematic equations - 1M
Find motion parameters - 2M

b) Givendata - 2M
Kinematic equations - 1M
Find motion parameters - 2M

10. a) Given data - 2M; Kinematic equations - 1M
Find Motion parameters - 2M

b) Given data - 2M; Kinematic equations - 1M
Find Motion parameters - 2M

11. Given data - 2M; Find I - 2M; Total M - 3M
Find α and θ - 2M

I B.Tech - II Semester - Regular/Supplementary Examination May - 2025

Engineering Mechanics (20CE3201, 23ME3201) KEY

PART - A

1.

a) Free body diagram - It is a diagram obtained after removing all the supports and replace them by reaction forces.

b) parallelogram law of forces - If two forces acting at a point be represented in magnitude and direction by the two adjacent sides of a parallelogram, then their resultant is represented in magnitude and direction by the diagonal of the parallelogram passing through that point.

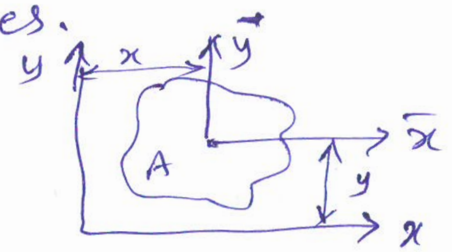
c) Types of trusses - perfect truss
deficient truss
redundant truss

other types - pratt, Howe, Fink, Warren, Baltimore, K truss, stadium, Bascule etc.

d) Static friction - It is the frictional force experienced by a body, when it is in a state of rest under the action of external forces.

Dynamic friction - It is the frictional force experienced by a body, when it is in a state of motion

e) parallel axis theorem - The moment of inertia of plane area with respect to any axis in its plane is equals to the moment of inertia with respect to the centroidal parallel axis plus the product of total area and square of the distance between the two axes.



$$I_x = \bar{I}_x + Ay^2$$

$$I_y = \bar{I}_y + Ax^2$$

f) Centroid - It is the point through which the whole area is assumed to be concentrated.

g) Examples of linear motion - falling of a stone, person running on a straight tract, car moving at a constant speed etc.

h) curvilinear motion - If the path of a body or particle is describes a curve, the body or particle is said to be in curvilinear motion.

i) Units of Angular velocity - rad/s

Angular acceleration - rad/s^2

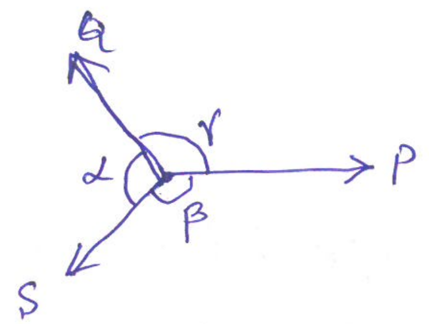
j) D'Alembert's principle - The algebraic sum of externally applied forces and inertia force in any given direction is zero.

$$\Sigma F + (-Ma) = 0$$

PART – B

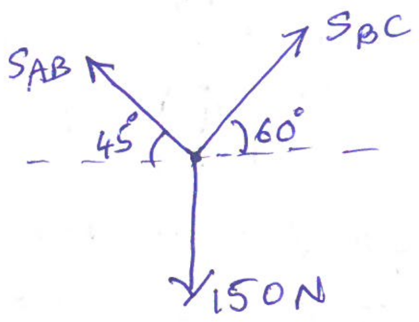
UNIT – I

2. a) Lami's theorem : If three coplanar forces acting at a point are in equilibrium, each force is proportional to the sine of angle between other two forces.



$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{S}{\sin\gamma}$$

b)



Applying Lami's theorem,

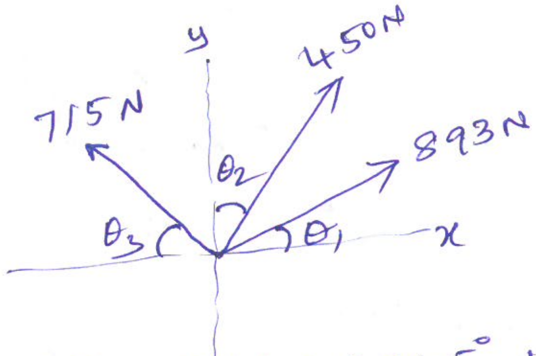
$$\frac{150}{\sin 75^\circ} = \frac{S_{AB}}{\sin 150^\circ} = \frac{S_{BC}}{135^\circ}$$

$\Rightarrow S_{AB} = 77.64\ N$

$\Rightarrow S_{BC} = 109.8\ N$

(OR)

3. a)



$\theta_1 = \tan^{-1}\left(\frac{1}{2}\right) = 26.5^\circ$

$\theta_2 = \tan^{-1}\left(\frac{3}{4}\right) = 36.8^\circ$

$\theta_3 = \tan^{-1}\left(\frac{2}{1}\right) = 63.4^\circ$

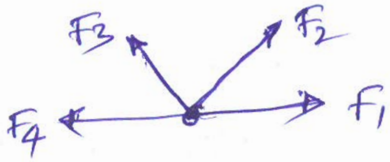
$\Sigma F_x = 893\cos 26.5^\circ + 450\sin 36.8^\circ - 715\cos 63.4^\circ$
$= 748.6\ N$

$\Sigma F_y = 893\sin 26.5^\circ + 450\cos 36.8^\circ + 715\sin 63.4^\circ$
$= 1398.1\ N$

Resultant, $R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2} = 1585.9\ N$

Direction, $\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right) = 61.83^\circ$

b) Coplanar system of forces: All the system of forces lie in the same plane.

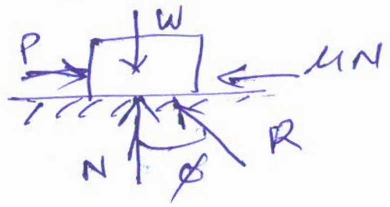


Non coplanar system of foces: Line of action of the forces may not lie in the same plane.

UNIT – II

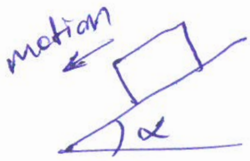
4. a) Angle of friction – The angle between resultant of Normal reaction and frictional force and the normal reaction is called angle of friction.

$\phi = \tan^{-1}\mu$

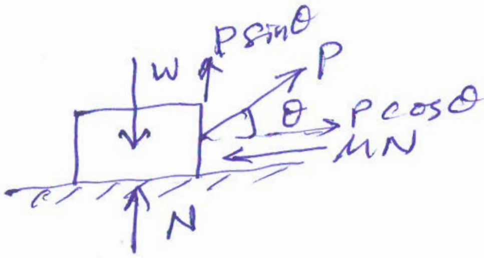


Angle of repose – The angle of inclination α, at which the body slides on its own is called angle of repose.

$\alpha = \phi$



b) $W = 300N$
$P = 200N$
$\mu = 0.8$



$\Sigma F_y = 0$: $N = W - P\sin\theta$

frictional force, $f = \mu N = \mu(W - P\sin\theta)$

To start motion, $P\cos\theta \geq \mu(W - P\sin\theta)$

$200\cos\theta \geq 0.8(300 - 200\sin\theta)$

$200\cos\theta \geq 240 - 160\sin\theta$

$$200\cos\theta + 160\sin\theta \geq 240$$

$$\cos\theta + 0.8\sin\theta \geq 1.2$$

Let $R = \sqrt{1^2 + 0.8^2} = 1.28$

$$\phi = \tan^{-1}\mu = \tan^{-1} 0.8 = 38.66^\circ$$

$$\cos\theta + 0.8\sin\theta = R\sin(\theta + \phi)$$

$$\sin(\theta + 38.66) \geq \frac{1.2}{1.28} = 0.9375$$

$$\theta + 38.66^\circ \geq \sin^{-1}(0.9375) = 69.83^\circ$$

$$\theta \geq 69.83 - 38.66 = 31.17^\circ$$

$$\therefore \theta_{min} = 31.17^\circ$$

$\because \sin(\theta + \phi) \leq 1$, maximum value occurs at

$$\sin(\theta + 38.66) = 1$$

$$\theta + 38.66^\circ = 90^\circ$$

$$\Rightarrow \theta_{max} = 90 - 38.66^\circ = 51.34^\circ$$

(OR)

5. a) Laws of friction

i) If friction is neglected, the reaction (N) is always normal to the surfaces in contact.

ii) Friction force is always opposite to the direction of motion of the body

iii) The magnitude of friction varies from zero to maximum adjusting itself to the resulting force tending to cause motion

iv) Friction force is independent of the velocity of sliding, shape and area of contact between the two surfaces and depends on the nature of surfaces in contact.

v) The limiting friction when motion impends $F_m = \mu_s N$

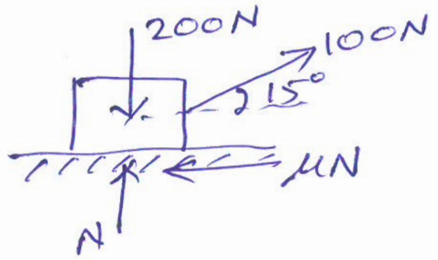
vi) If motion occurs, kinetic force of friction $F_K = \mu_K N$

vii) Angle of friction is $\phi = \tan^{-1}\left(\frac{F_m}{N}\right)$

b) $W = 200N$

$P = 100N$

$\theta = 15°$



$\Sigma F_y = 0;\quad N + 100\sin 15° - 200 = 0$

$\Rightarrow N = 174.1\ N$

$\Sigma F_x = 0;\quad 100\cos 15° - \mu N = 0$

$\Rightarrow \mu = \frac{100\cos 15}{174.1} = 0.554$

UNIT - III

6.

a)

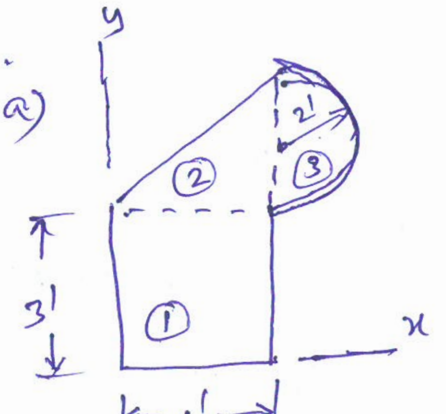


Figure	Area	x	y
1	12	2	1.5
2	8	2.67	4.33
3	6.28	4.85	6

$$\bar{x} = \frac{A_1x_1 + A_2x_2 + A_3x_3}{A_1 + A_2 + A_3}$$

$$= \frac{(12\times 2) + (8\times 2.67) + (6.28\times 4.85)}{12 + 8 + 6.28} = 2.88'$$

$$\bar{y} = \frac{A_1y_1 + A_2y_2 + A_3y_3}{A_1 + A_2 + A_3}$$

$$= \frac{(12\times 1.5) + (8\times 4.33) + (6.28\times 6)}{12 + 8 + 6.28} = 3.3'$$

b)

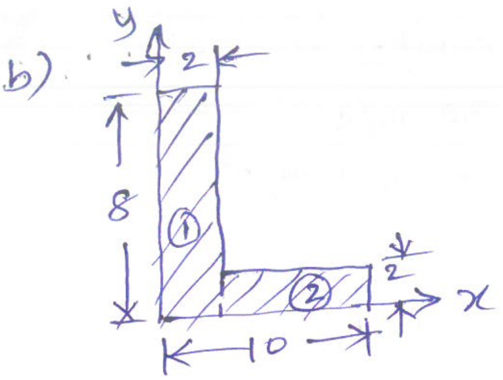


Figure	Area	x	y
1	16	1	4
2	16	6	1

$$\bar{x} = \frac{A_1 x_1 + A_2 x_2}{A_1 + A_2}$$

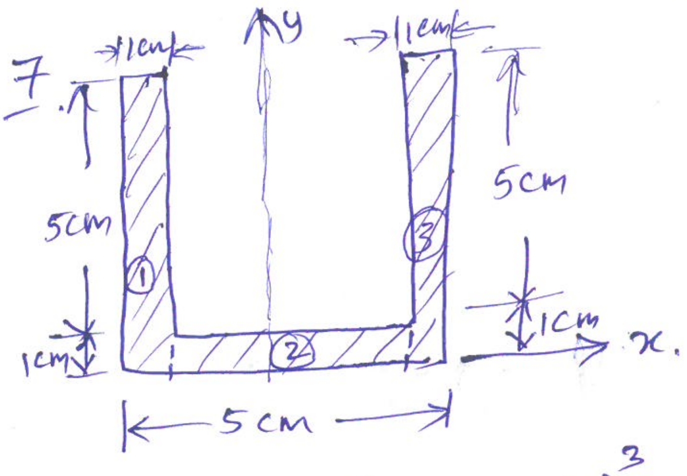
$$= \frac{(16 \times 1) + (16 \times 6)}{16 + 16} = 3.5\,cm$$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$= \frac{(16 \times 4) + (16 \times 1)}{16 + 16} = 2.5\,cm$$

(OR)

7.



$$I_x = \frac{1(6)^3}{3} + \frac{3(1)^3}{3} + \frac{1(6)^3}{3} = 78.538\ cm^4$$

$$I_y = \left\{\frac{6(1)^3}{12} + 6(2)^2\right\} + \frac{1(3)^3}{12} + \left\{\frac{6(1)^3}{12} + 6(2)^2\right\}$$

$$= 2.25\ cm^4$$

UNIT – IV

8. a) i) $v = u + at$

$v = 0\ m/s$
$u = 30\ m/s$
$g = -9.81\ m/s^2$

$$0 = 30 + (-9.81)t$$

$$\Rightarrow t = \frac{30}{9.81} = 3.06 \text{ second}$$

ii) $v^2 - u^2 = 2as$

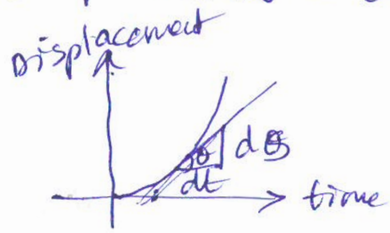
$$0^2 - 30^2 = 2(-9.81)s$$

$$\Rightarrow s = \frac{30^2}{2 \times 9.81} = 45.9\ m$$

iii) $v = u = 30\ m/s$

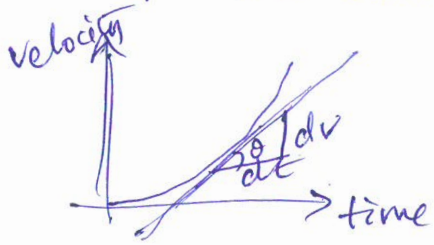
iv) $t = t_{ascend} + t_{descend} = 2 \times 3.06 = 6.12$ Seconds

b) Displacement – time curve



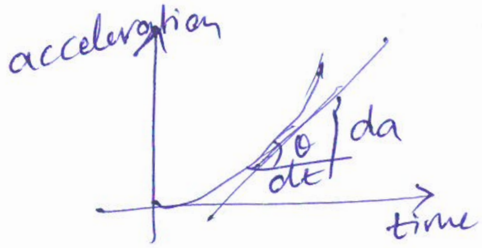
$\tan\theta = \frac{ds}{dt} = v$

Velocity – time curve



$\tan\theta = \frac{dv}{dt} = a$

Acceleration – time curve



$\tan\theta = \frac{da}{dt} = \text{Jerk}$

(OR)

9. a) i) $s = ut + \frac{1}{2}at^2$

$s = 200$

$u = 80 \text{ kmph} \times \frac{5}{18}$

$= 22.22 \text{ m/s}$

$t = 10 \text{ second}$

$200 = 22.22(10) + \frac{1}{2}(a)(10)^2$

$\Rightarrow a = -0.444 \text{ m/s}^2$

ii) $v = u + at$

$= 22.22 + (-0.444)(10)$

$= 17.78 \text{ m/s}$

b) $u = 0$, $v = 80 \text{ kmph} \times \frac{5}{18} = 22.22 \text{ m/s}$, $s = 1200 \text{m}$

$v^2 - u^2 = 2as$

$(22.22)^2 - 0^2 = 2(a)(1200)$

$\Rightarrow a = 0.2057 \text{ m/s}^2$

time taken to reach maximum speed,

$v = u + at_1$

$t_1 = \frac{v-u}{a} = \frac{22.22 - 0}{0.2057} = 108 \text{ Seconds}$

time taken for travel at constant speed for S = 18 km

$s = vt - \frac{1}{2}at^2$ $\quad \because v = \text{constant}, a = 0$

$s = vt_2$

$t_2 = \frac{s}{v} = \frac{1800}{22.22} = 81 \text{ seconds}$

distance travelled before coming to rest,

$s = \frac{v+u}{2} \times t$

$u = 22.22 \text{ m/s}$

$v = 0$

$t = 3$ ~~seconds~~ minutes

$= 180$ seconds

$= \frac{22.22}{2} \times 180$

$= 2000 \text{ m}$

$\therefore$ Total distance travelled $= 1200 + 1800 + 2000 = 5000 \text{m}$

Total time elapsed $= 108 + 81 + 180 = 369$ seconds.

UNIT-V

10. a) $\omega_0 = 0$; $\omega = 20$ rad/s ; $d = 0.5$ m ; $t = 3$ sec

$v = \omega \cdot r = 20 \times \frac{0.5}{2} = 5$ m/s

$\omega = \omega_0 + \alpha t \Rightarrow 20 = 0 + \alpha(3)$

$\Rightarrow \alpha = 6.67$ rad/s^2

$a_t = \alpha \cdot r = 6.67 \times \frac{0.5}{2} = 1.67$ m/s^2

$a_n = \frac{v^2}{r} = \frac{5^2}{0.5/2} = 100$ m/s^2

b) $N_0 = 1800$ rpm $\Rightarrow \omega_0 = \frac{2\pi \times 1800}{60} = 188.5$ rad/s

$N = 0$

$t = 320$ seconds

$\omega = \omega_0 + \alpha t \Rightarrow 0 = 188.5 + \alpha(320)$

$\Rightarrow \alpha = -0.589$ rad/s^2

$\omega^2 - \omega_0^2 = 2\alpha\theta \Rightarrow 0^2 - 188.5^2 = 2(-0.589)\theta$

$\Rightarrow \theta = 30163$ radians

(OR)

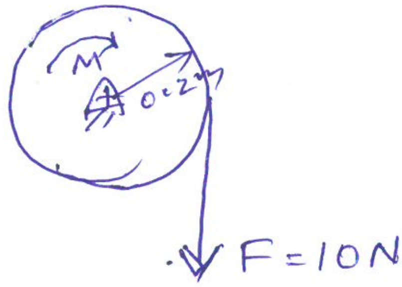
11. $M = 5$ N-m

$R = 0.2$ m

$m = 30$ kg

$\omega_0 = 0$

$\omega = 20$ rad/s



$I = \frac{1}{2} m R^2$

$= \frac{1}{2} \times 30 \times (0.2)^2$

$= 0.6$ kg-m^2

Moment produced due to F, $= 10 \times 0.2$

$= 2$ N-m

Total moment, $\Sigma M = 5 + 2 = 7$ N-m

Newton's equation of motion,

$\Sigma M = I\alpha$

$7 = 0.6 \times \alpha \Rightarrow \alpha = 11.67$ rad/s^2

$\omega^2 - \omega_0^2 = 2\alpha\theta \Rightarrow 20^2 - 0^2 = 2(11.67)\theta \Rightarrow \theta = 17.14$ rad

No. of revolutions $= \frac{\theta}{2\pi} = 2.72$ rev.