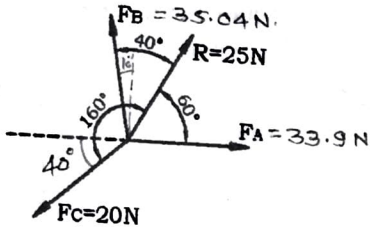
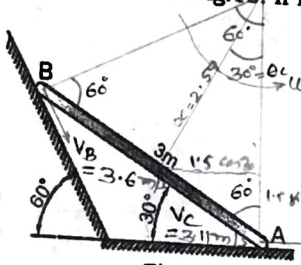
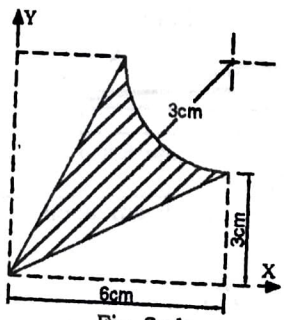
210411

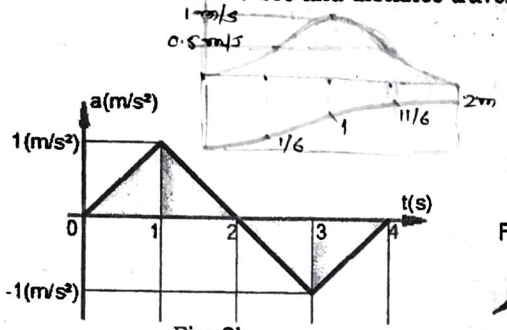
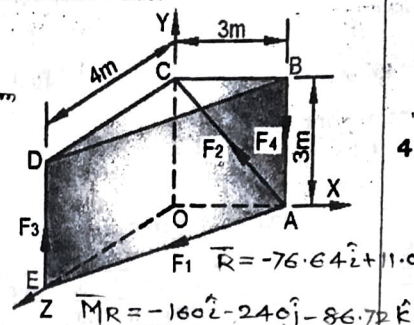
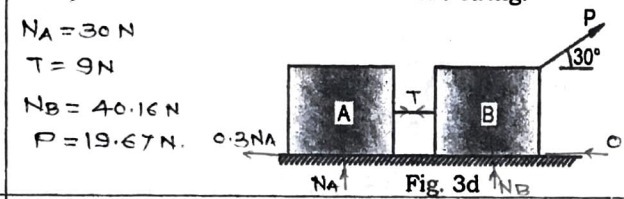
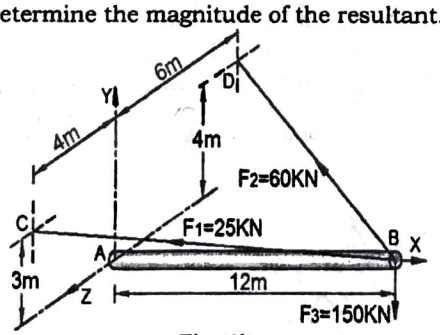
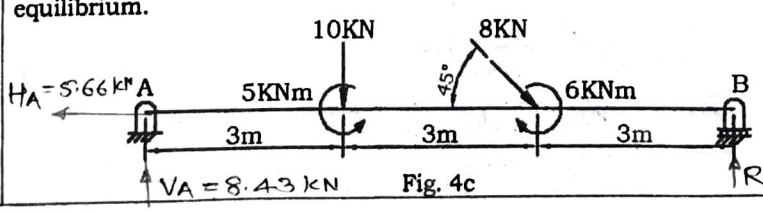
PILLAI COLLEGE OF ENGINEERING, NEW PANVEL
(Autonomous) (Accredited 'A+' by NAAC)
END SEMESTER EXAMINATION
SECOND HALF 2021
BRANCH: FE (Mech/Auto/EXTC)

Subject: Engineering Mechanics
Max. Marks: 60
N.B 1. Q.1 is compulsory
2. Attempt any two from the remaining three questions

Time: 02.00 Hours
Date: 11-04-2022

Q.1.	Attempt all	M	BT	CO
a)	State Varignon's Theorem with example.	5	2,3	1
b)	A particle is moving along the path $\bar{r} = (8t^2)\bar{i} + (t^3+5)\bar{j}$ m. where 't' in sec. Determine magnitude of particle's velocity and acceleration when t=3sec. Also determine the equation y = f(x) of the path. $V = 55.07$ m/s, $\theta_V = 29.35°$, $a_T = 24.08$ m/s², $R = 386.65$ m, $a_N = 7.38$, $a_T = 25.32$ m/s², $\theta_a = 17.03°$, $y = (\frac{x}{8})^{3/2} + 5$	5	4,5	5
c)	A force R=25N has components F_A, F_B and F_C as shown in Fig.1b. If F_C=20N. Find F_A and F_B.  Fig. 1c  Fig. 1d	5	4,5	1,3
d)	A bar AB, 3m long, slides down the plane as shown in Fig. 1d. The velocity of end A is 3.6m/s to the right. Determine: (i) The angular velocity of AB (ii) Velocity of end, B and (iii) Velocity of center C at the instant.	5	4,5	5
Q.2.	Attempt all			
a)	Show that Angle of friction is equal to Angle of Repose.	4	2,3	4
b)	A soldier fires a bullet with a velocity of 31.32m/sec at an angle α upwards from the horizontal from his position on a hill to strike a target which is 100m away and 50m below his position. Find the angle of projection α. Find also the velocity with the bullet strikes the object. $\alpha = 63.43°$ OR $0°$, $V_x = 14$ m/s, $V_y = 42.02$ m/s, $V = 44.29$ m/s, $\theta_V = 71.58°$	4	4,5	5
c)	Find the centroid of the shaded area about centroidal x and y axis as shown in Fig. 2cd. $\bar{x} = \bar{y} = 2.71$ cm $I_{\bar{x}} = I_{\bar{y}} = 14.02$ cm⁴  Fig. 2cd	6	4,5	2
d)	Find the MI of the shaded area about centroidal x and y axis as shown in Fig. 2cd.	6	4,5	2

P. T. O.

Q.3.	**Attempt all**			
a)	Explain: Principle of Transmissibility, Lamis Theorem	4	1,2	1,3
b)	For the acceleration-time diagram of a particle shown in Fig. 3b, calculate velocity at the end of 3 sec and distance travelled in 4 sec.  Fig. 3b	4	4,5	5
c)	Find the resultant of the given force system shown in Fig. 3c. If F_1=100N; F_2=20 N; F_3=40N; F_4=40N. Also Find moment of resultant about 'O'.  $\bar{R} = -76.64\hat{i} + 11.09\hat{j} + 80\hat{k}$ $\bar{M}_R = -160\hat{i} - 240\hat{j} - 86.72\hat{k}$ Fig. 3c	6	4,5	1
d)	Two blocks W_A=30N, and W_B=50N are placed on a rough horizontal plane. μ_A=0.3 and μ_B=0.2 Find the minimum value of force 'P' required to just move the system. Also find the tension in the string.  $N_A = 30$ N $T = 9$ N $N_B = 40.16$ N $P = 19.67$ N. Fig. 3d	6	4,5	4
Q.4.	**Attempt all**			
a)	Acceleration of a particle is given by $a=90-6x^2 cm/s^2$, where x in cm. If particle starts with zero initial velocity from origin, determine velocity when x=5cm, position where velocity again zero, position where velocity is maximum. $V_{x=5} = 20$ cm/s, $x = 6.71$ cm, $x_{V\,max} = 3.87$ cm.	4	4,5	5
b)	Three forces F_1, F_2 and F_3 act at B. Find the resultant of these forces in vector form. Also determine the magnitude of the resultant. $\bar{R} = -74.50\hat{i} - 127.08\hat{j} - 18.02\hat{k}$ $R = 148.42$ KN  Fig. 4b	4	4,5	1
c)	Find the reactions at the supports of the beam applying conditions of equilibrium.  $H_A = 5.66$ kN $V_A = 8.43$ KN $R_B = 7.22$ KN Fig. 4c	6	4,5	3

d)	A ladder of length 4m weighing 200N is placed against a vertical wall as shown in Fig.24. The coefficient of friction between the wall and the ladder is 0.2 and that between the floor and the ladder is 0.3. The ladder in addition to its own weight has to support a man weighing 600N at a distance of 3m from A. Calculate the minimum horizontal force to be applied at A to prevent slipping.	6	4,5	4

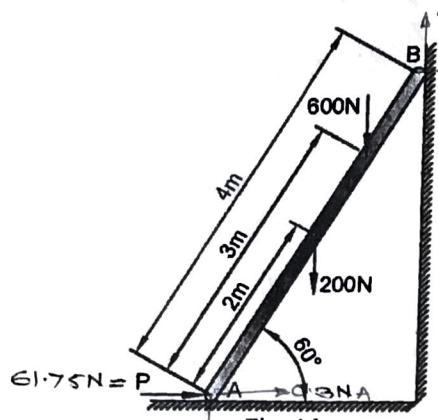


Fig. 4d

CO1-Illustrate the concept of force, moment and apply the same along with the concept of equilibrium in two and three dimensional systems with the help of FBD.

CO2-Determine the centroid and MI of plane lamina.

CO3-Apply equilibrium equations in statics.

CO4-Evaluate coefficient of friction between the different surfaces in contact.

CO5-Establish relation between velocity and acceleration of a particle and analyze the motion by plotting the relation.

CO6-Apply Newton's law in motion, and identify different kinds of particle motions.

BT Levels: - 1 Remembering ,2 Understanding, 3 Applying,4 Analyzing, 5 Evaluating, 6 Creating.

M-Marks, BT- Bloom's Taxonomy, CO-Course Outcomes.

1.b) $\bar{r} = (8t^2)\hat{i} + (t^3+5)\hat{j}$

$\bar{v} = (16t)\hat{i} + (3t^2)\hat{j}$

$\bar{a} = (16)\hat{i} + (6t)\hat{j}$

$V|_{t=3} = \sqrt{(16\times3)^2 + (3\times3^2)^2}$

$= 55.07$ m/s

$\theta_V = 20.36°$

$a_{t=3} = \sqrt{(16)^2 + (6\times3)^2}$

$= 24.08$ m/s^2

$R = \left| \frac{(V_x^2 + V_y^2)^{3/2}}{V_x a_y - V_y a_x} \right|$

$\therefore R = \left| \frac{[(16\times3)^2 + (3\times3^2)^2]^{3/2}}{16\times3\times6\times3 - 3\times3^2\times16} \right|$

$= 386.65$ m

$a_N = \frac{V^2}{R} = 7.38$ m/s^2

$a_{Tot} = \sqrt{a_T^2 + a_N^2}$

$= 25.32$ m/s^2

$\theta_{a_{tot}} = 17.02°$

$x = 8t^2$

$\therefore t = \left(\frac{x}{8}\right)^{1/2}$ $\therefore y = \left(\frac{x}{8}\right)^{3/2} + 5$

1.c) $25\sin60 = F_B\cos10 - 20\sin40$

$\therefore F_B = 35.04$ N.

$25\cos60 = F_A - F_B\sin10 - 20\cos40$

$\therefore F_A = 33.90$ N

1.d) $OA = 3$m, $OB = 3$m

$V_A = OA \cdot \omega$ $V_B = OB \times \omega$

$3.6 = 3.\omega$ $= 3.6$ m/s

$\therefore \omega = 1.2$ rad/s

2.b) $y = x\tan\alpha - \frac{1}{2}\frac{gx^2}{u^2}(1+\tan^2\alpha)$

$-50 = 100\tan\alpha - \frac{1}{2}\frac{g\cdot100^2}{81.32^2}(1+\tan^2\alpha)$

$\therefore \tan\alpha = 2$ $\therefore \alpha = 63.43°$ or $0°$

$u_x = V_x = 81.32\cos(63.43) = 14$ m/s $\}$ $V = 44.24$ m/s

$v^2 = u^2 + 2gh$, $V_y = 42.02$ m/s $\}$ $\theta_V = 71.56°$

2.c)

6	36	3	3	$\frac{6\times6^3}{12}$	$\frac{6\times6^3}{12}$
6	-9	1	4	$-\frac{3\times6^3}{36}$	$-\frac{6\times3^3}{36}$
3	-9	4	1	$-\frac{6\times3^3}{36}$	$-\frac{3\times6^3}{36}$
R=3	$-\frac{9\pi}{4}$	$6-\frac{4}{\pi}$	$6-\frac{4}{\pi}$	$-\frac{81}{2}\times3^4$	$-\frac{81}{2}\times3^4$

$\bar{x} = \bar{y} = 2.71$ cm. $I_x = I_y = 81.045$

$Ay^2 = -67.01$.

$I_{\bar{x}} = I_{\bar{y}} = 14.02$ cm^4

Q.3.c)

$\bar{F}_1 = -60\hat{i} + 0\hat{j} + 80\hat{k}$

$\bar{F}_2 = -16.6\hat{i} + 11.09\hat{j} + 0\hat{k}$

$\bar{F}_3 = 0\hat{i} + 40\hat{j} + 0\hat{k}$

$\bar{F}_4 = 0\hat{i} - 40\hat{j} + 0\hat{k}$

$\bar{R} = -76.64\hat{i} + 11.09\hat{j} + 80\hat{k}$

$\bar{M}_1 = 0\hat{i} - 240\hat{j} + 0\hat{k}$

$\bar{M}_2 = 0\hat{i} + 0\hat{j} + 33.28\hat{k}$

$\bar{M}_3 = -160\hat{i} + 0\hat{j} + 0\hat{k}$

$\bar{M}_4 = 0\hat{i} + 0\hat{j} - 120\hat{k}$

$\bar{M}_R = -160\hat{i} - 240\hat{j} - 86.72\hat{k}$

Q4.a.

$a = (90 - 6x^2)$

$v\frac{dv}{dx} = (90 - 6x^2)$

$\int v\,dv = \int (90 - 6x^2)\,dx$

$\frac{v^2}{2} = 90x - 6\cdot\frac{x^3}{3} + c_1$

At $x = 0$, $v = 0$ $\therefore c_1 = 0$

$\frac{v^2}{2} = 90x - 2x^3$

At $x = 5$

$v = 20$ cm/s

$0 = 90x - 2x^3$

$\therefore x = 6.71$ cm.

$90 - 6x^2 = 0$

$x = 3.87$ cm.

Q.4b)

$\bar{F}_1 = -28.07\hat{i} + 5.76\hat{j} - 7.69\hat{k}$

$\bar{F}_2 = -51.42\hat{i} + 17.14\hat{j} - 25.71\hat{k}$

$\bar{F}_3 = 0\hat{i} - 150\hat{j} + 0\hat{k}$

$\bar{R} = -74.50\hat{i} - 127.08\hat{j} - 18.02\hat{k}$

$R = 148.42$ kN.