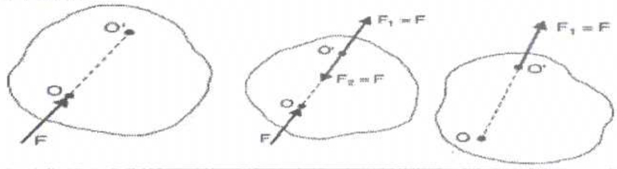
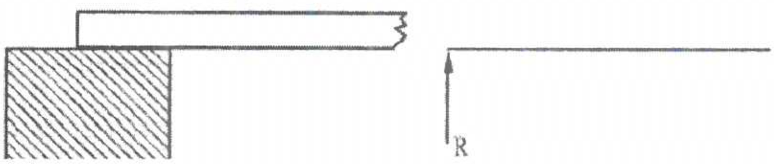
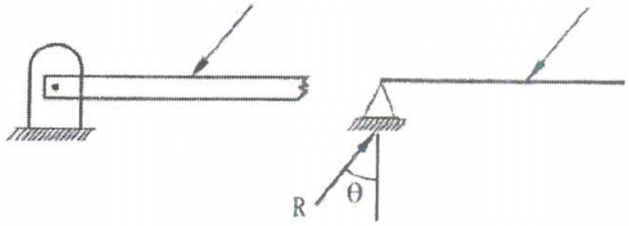
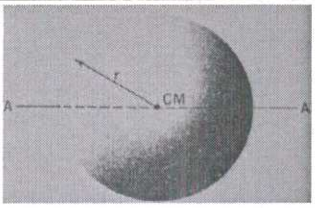
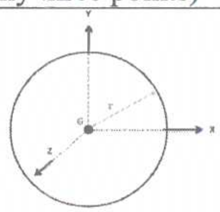
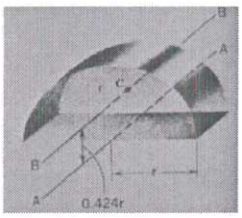
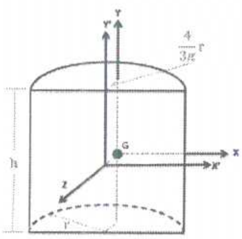
VERSION : A

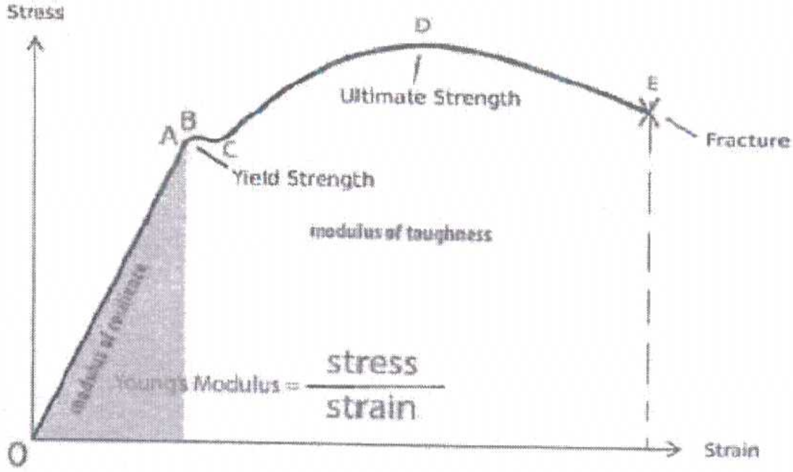
Scoring Indicators

COURSE NAME: ENGINEERING MECHANICS

COURSE CODE: 2021 **QID: 2106220014**

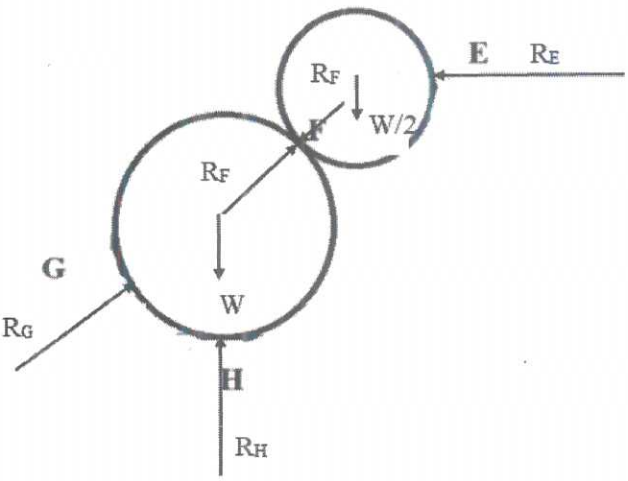
Q.No	Scoring Indicators	Split score	Sub Total
	PART A		**9**
I.1	Coplannar colllinear	1	1
I.2	Unit of length, mass, time (any two)	½, ½	1
I.3	Loads are applied at certain point in the beam. Also called point load.	1	1
I.4	A frame which is composed of such members, which are just sufficient to keep the frame in equilibrium.	1	1
I.5	4R/3π	1	1
I.6	$(BD^3\text{-}bd^3)/12$	1	1
I.7	Compressive stress	1	1
I.8	Shear force/ shear area	1	1
I.9	Change in volume/ change in pressure OR Direct stress/volumetric strain	1	1
	PART B		**24**
II.1	It states that if a force , acting at a point on a rigid body, is shifted to any other point which is on the line of action of the force, the external effect of the force on the body remain unchanged. Any force acting at a point on a rigid body can be transmitted to act at any other point along its line of action without changing its effect on the rigid body. This proves the principle of transmissibility of a force. 	Exp (2) Fig(1)	3
II. 2	$\sum H = 100 \cos 20^0 - 200 \sin 30^0 - 300 \sin 40^0 = -198.86$ N $\sum V = 100 \sin 20^0 + 200 \cos 30^0 - 300 \cos 40^0 = -22.40$ N $R = \frac{\sqrt{H^2+V^2}}{} = 200.11$ N	1 1 1	3
II. 3	Frame is perfect frame, load is applied at joints only, all members are hinged or pin jointed	1 1 1	3
II. 4	When the end of a beam is kept simply on a smooth flat support is called simple support. 	1 Fig (1)	3

	The beam is hinged or pinned to another rigid member. The beam can rotate about hinge.  	1	
II. 5	1. The force of friction acts in the opposite direction in which surface is having tendency to move. 2. The force of friction is equal to the force applied to the surface, so long as the surface is at rest. 3. When the surface is on the point of motion, the force of friction is maximum and this maximum frictional force is called the limiting friction force. 4. The limiting frictional force bears a constant ratio to the normal reaction between two surfaces. 5. The limiting frictional force does not depend upon the shape and areas of the surfaces in contact. 6. The ratio between limiting friction and normal reaction is slightly less when the two ırfaces are in motion. 7. The force of friction is independent of the velocity of sliding. The above laws of solid friction are also called laws of static and dynamic friction. (Any three points)	1 1 1	3
II.6	 OR  Sphere  OR  Semi circular cylinder	Fig. 1.5 Fig. 1.5	3
II.7	It states that if the moment of inertia of a plane area about an axis in the plane of area through the C.G. of the plane area be represented by I_G, then the moment of the inertia of the given plane area about a parallel axis *AB* in the plane of area at a distance *h* from the C.G. of the area is given by $I_{AB} = I_G + Ah^2$. where I_{AB} = Moment of inertia of the given area about *AB* I_G = Moment of inertia of the given area about C.G. A = Area of the section h = Distance between the C.G. of the section and the axis *AB*.	Exp. 2 1	3

<table>
<tr><td>II.8</td><td>
</td><td>Fig(2)

Points.
1</td><td>3</td></tr>
<tr><td>II.9</td><td>Stiffness is the extent to which an object resist deformation in response to an applied force.
$K=F/\delta$

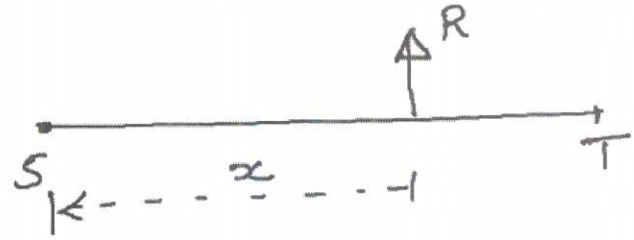
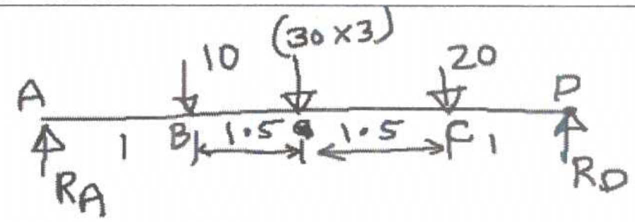
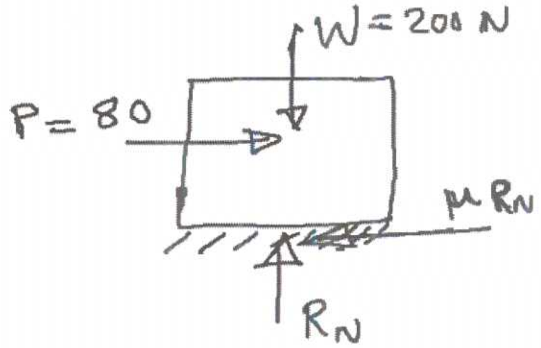
Hardness is the resistance of a material to localized plastic deformation.</td><td>1.5

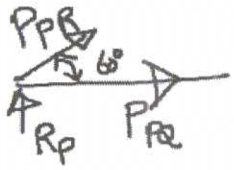
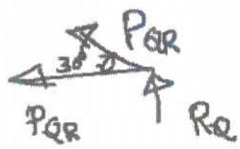
1.5</td><td>3</td></tr>
<tr><td>II.10</td><td>$\sigma = P/A = P/(\pi d^2/4)$
$= 900/(3.14 * 30*30/4) = 1.27 N/mm2$
$\varepsilon = \delta l/l = 0.06/500 = 0.00012$</td><td>1
1
1</td><td>3</td></tr>
<tr><td></td><td>PART C</td><td></td><td>42</td></tr>
<tr><td>III.1</td><td>

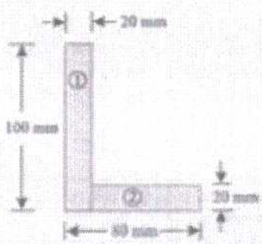
Free body diagram.
The forces are:
Reaction R_H at point H,
Reaction R_G at point G,
Reaction R_E at point E,
Reaction R_F at point F,
Weight W of the biggest ball
Weight W/2 of the small ball

OR</td><td>Dia gram (4)

3</td><td>7</td></tr>
</table>

III.2		Fig-2	7
		1	
	$\sum F_y = o$	1	
	$R = 400 - 300 + 200 - 100$		
	$= 400$ N	1	
	$\sum M_S = 0$		
	$(400\times1) - (300\times3) + (200\times4) + (100\times6) + (R\times x) = 0$	2	
	Substitute R in above equation		
	x = 2.25M		
III.3		Fig-2	7
	$\sum F_V = 0$	1	
	$R_A + R_D - 10 - (30\times3) - 20 = 0$	1	
	$\sum M_A = 0$	1	
	$(10 \times1) + (90\times2) + (20\times4) - (R_D\times5) = 0$		
	$R_D = 63$ N	1	
	$R_A = 57$ N	1	
	OR		
III.4		Fig-2	7
	Resolving forces along vertical direction,		
	$R_N - W = 0$	2	
	$R_N = 200$ N		
	Since P just causes the motion,	1	
	$\mu R_N = P$	2	
	$\mu = 0.4$		

III.5		Fig.-2	7
	From geometry, PR = 5M $R_P + R_Q = 200$ $(R_Q \times 10) - (200 \times 2.347) = 0$	1	
	$R_Q = 46.94$ N $R_P = 153.05$ N Consider joint P	1	
	$P_{PR} \sin 60 + R_P = 0$ $P_{PR} = -176.73$ N	1	
	$P_{PQ} + P_{PR} \cos 60 = 0$ $P_{PQ} = 88.36$ N	1	
	Consider joint Q $R_Q + P_{QR} \sin 30 = 0$ $P_{QR} = -93.88$ N	1	
	OR		
III.6	<u>**Static Friction**</u> Static friction is defined as the frictional force that acts between the surfaces when they are at rest with respect to each other. The magnitude of the static force is equal in the opposite direction when a small amount of force is applied. When the force increases, at some point maximum static friction is reached. Static Friction Examples Following are the examples of static friction:	2	7

	• Skiing against the snow • Creating heat by rubbing both the hands together • Table lamp resting on the table <u>Sliding Friction</u> Sliding friction is defined as the resistance that is created between any two objects when they are sliding against each other. <u>Examples Of Sliding Friction</u> Following are the examples of sliding friction: • Sliding of the block across the floor • Two cards sliding against each other in a deck <u>Rolling Friction</u> Rolling friction is defined as the force which resists the motion of a ball or wheel and is the weakest types of friction. Examples Of Rolling Friction Following are the examples of rolling friction: • Rolling of the log on the ground • Wheels of the moving vehicles <u>Fluid Friction</u> Fluid friction is defined as the friction that exists between the layers of the fluid when they are moving relative to each other. Examples Of Fluid Friction Following are the examples of fluid friction: • The flow of ink in pens • Swimming		2 2 1	
III.7	(i) *Rectangle 1* $a_1 = 100 \times 20 = 2000\ mm^2$ $x_1 = \frac{20}{2} = 10\ mm$ and $y_1 = \frac{100}{2} = 50\ mm$ (ii) *Rectangle 2* $a_2 = (80 - 20) \times 20 = 1200\ mm^2$ $x_2 = 20 + \frac{60}{2} = 50\ mm.$ and $y_2 = \frac{20}{2} = 10\ mm$ We know that distance between centre of gravity of the section and left face, $\bar{x} = \frac{a_1 x_1 + a_2 x_2}{a_1 + a_2} = \frac{(2000 \times 10) + (1200 \times 50)}{2000 + 1200} = 25\ mm$ Ans. Similarly, distance between centre of gravity of the section and bottom face, $\bar{y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2} = \frac{(2000 \times 50) + (1200 \times 10)}{2000 + 1200} = 35\ mm$ Ans. 		Fig-2 1 1 1 1 1	

OR

III.8 **Section-1**

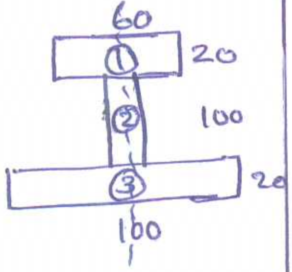


Fig-2

$a_1 = 60 \times 20 = 1200\,mm^2$

$y_1 = 20 + 100 + \left(\frac{20}{2}\right) = 130\,mm$

Section-2

$a_2 = 100 \times 20\,mm^2$

$y_2 = 20 + \left(\frac{100}{2}\right) = 70\,mm$ 7

Section-3 $a_3 = 20 \times 100\,mm^2$, $y_3 = 10\,mm$ 1

$\bar{y} = \frac{a_1 y_1 + a_2 y_2 + a_3 y_3}{a_1 + a_2 + a_3} = 60.8\,mm$

$I_{G_1} = \frac{bd^3}{12} = 40 \times 10^3\,mm^4$ 1

$h_1 = 130 - 60.8 = 69.2\,mm$

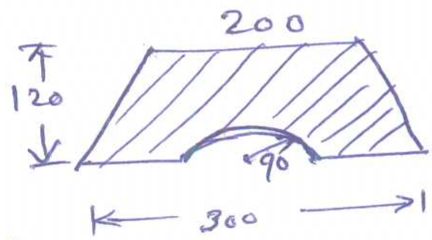
$I_{G_2} = 1666.7 \times 10^3\,mm^4$, $h_2 = 70 - 60.8 = 9.2\,mm$ 1

$I_{G_3} = 66.7 \times 10^3\,mm^4$, $h_3 = 60.8 - 10 = 50.8\,mm$ 1

$I_{xx} = \left(I_{G_1} + A_1 h_1^2\right) + \left(I_{G_2} + A_2 h_2^2\right) + \left(I_{G_3} + A_3 h_3^2\right)$ 1

$= 12850 \times 10^3\,mm^4$

III.9



Trapezium

$a_1 = 120 \times \left(\frac{200+300}{2}\right) = 30000\,mm^2$ 1

$y_1 = \frac{120}{3}\left[\frac{300 + (2 \times 200)}{300 + 200}\right] = 56\,mm$ 1 7

Semi circle $a_2 = \frac{\pi}{2} r^2 = 4050\,\pi\,mm^2$ 1

$y_2 = \frac{4r}{3\pi} = \frac{120}{\pi}\,mm$ 1

$\bar{y} = \frac{a_1 y_1 - a_2 y_2}{a_1 - a_2} = 69.1\,mm$ eqn (2) Ans (1)

III.10	**OR** MOI of rectangle ABCD about AB $I_{AB}= I_G+Ah^2$ $= (20×25^3)/12+(20×25×(25/2)^2$ $= 104167cm^4$ MOI of semicircle about DC $I_{DC} = (\pi d^4/64)/2$ $= (1/2)× (\pi×20^4)/64$ $= 3925cm^4$ $h = 4r/3\pi$ $= (4×10)/3\pi$ $= 4.24cm$ Area of a semicircle = $\pi r^2/2$ $=\pi×10^2/2$ $= 157.1\ cm^2$ MOI of semicircle about a lone through its CG parallel to CD $I_G = I_{DC} -Ah^2$ $= (3925-157.1) × 4.24^2$ $= 3925-2824.28$ $= 1100.72cm^4$ Distance of CG of semicircle from AB $= 25-4.24$ $= 20.76cm$ MOI of semicircle from AB $I_{AB}= I_G+Ah^2$ $= 1100.72+157.1× 20.76^2$ $= 1100.72+67706.58$ $= 68807.30cm^4$ MOI of shaded portion about AB $= 104167-68807.30 = 35359.7cm^4$	1 1 1 1 1 1 1	7
III.11	Given l=2000 mm d= 30 mm P=40000 N $E = 3×10^5\ N/mm^2$ $\sigma = P/A$ = 40000 /(3.14×30×30/4) = 56.617 N/mm2 $E= \sigma/\varepsilon$ $\varepsilon = \sigma/E$ = 56.617/(3×105) = 1.887×10-4 $\varepsilon= \delta l/l$ $\delta l = \varepsilon l$ = 0.377mm **OR**	1 1 1 1 1 1 1	7

III.12		1	
	Given		
	P=5000KN		
	l=2000 mm	1	
	b = 300 mm		
	d = 400 mm		
	dl = 0.9 mm	1	
	db = 0.05 mm	1	
	longitudinal strain = ε= dl/l = 4.5×10^{-4}	1	
	lateral strain = db/b = 1.66×10^{-4}		
	Poisson's ratio = lateral strain/longitudinal strain = 0.37		
	ε= σ/E		
	E = (P/A)/ε	2	
	= $[(5000\times10^{3})/(3.14\times400^{2}/4)]/(4.5\times10^{-4})$		
	= 88.46×10^{3} N/mm^{2}	1	