## DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE RAIGAD -402 103

Answer book of Mid Semester Examination - October - 2017

Branch: Group B
Sem.:- I
Subject with Subject Code:-Engineering Mechanics ME 102
Marks: 20
Date:- 03/10/2017
Time:- 1 Hr.
Instructions:- Assume the appropriate data if not given
Q. No. 1 Fill in the blanks
a) The Free body diagram of a body we remove all the supports and replace them by the reactions which these supports exert on the body. (subtract, remove, add, replace, represent)
b) Moment of a force about a point is equal to the product of the forces and perpendicular distance of the point from the line of action of the force. (addition, multiplication, product, parallel, perpendicular, equal)
c) Frame is a structure consisting of several bars or members pinned together and in which one or more than one of its members is subjected to more than tWO forces. (one, two, several, fix)
Q. No. 2 Attempt any one of the following:
a) A uniform wheel 60 cm in diameter rests against a rigid rectangular block 15 cm thick as shown in the figure. Find the least pull force $P$ through the centre of the wheel to just turn the wheel over the corner of the block. All surfaces are smooth. Find also the reaction of the block. The wheel weights 10,000 newtons.

Solution. The force $P$ has a tendency to turn the wheel about $B$ with the turning moment equal to the product of the force and the perpendicular distance of the line of action of $P$ and $B$. (see Fig. 46).
For a fixed turning moment, the force is the least if the moment arm is the maximum. The maximum value of the $a r m=B O$ since the force passes through $O$. Hence the least force $P$ should be in a direction


Fig. 45. on the wheel and keeping it in equilibrium are:
(i) The reaction $R_{B}$ of the block, (ii) The force $P$,
(iii) The weight $W=10000 \mathrm{~N}$ of the wheel acting vertically downwards through $O$,
(iv) The reaction $R_{A}$ between the block and the ground.
When the force applied is just sufficient to overturn the wheel there will be no pressure between the wheel and the horizontal surface at $A$. Hence $R_{A}=0$.
These forces are shown in Fig. 47.


Fig. 46.

Applying Lami's theorem 46.

$$
\begin{array}{ll} 
& \frac{W}{\sin 90^{\circ}}=\frac{R_{B}}{\sin \angle P O A}=\frac{P}{\sin \angle D O A} . \\
\text { Let } & \angle B O A=\theta \\
\therefore & \angle P O A=\left(90^{\circ}+\theta\right) \quad \text { and } \quad \angle D O A=\left(180^{\circ}-\theta\right) . \\
\therefore & \frac{W}{\sin 90^{\circ}}=\frac{R_{B}}{\sin \left(90^{\circ}+\theta\right)}=\frac{P}{\sin \left(180^{\circ}-\theta\right)}
\end{array}
$$

or

$$
\begin{equation*}
\frac{W}{1}=\frac{R_{B}}{\cos \theta}=\frac{P}{\sin \theta} \tag{i}
\end{equation*}
$$

Referring to Fig. 47 (b).

$$
\begin{array}{ll}
\cos \theta=\frac{O C}{O B}=\frac{15}{30} & \text { or } \quad \frac{1}{2} . \\
\therefore \quad \sin \theta=\sqrt{1-\left(\frac{1}{2}\right)^{2}}=\frac{\sqrt{3}}{2} .
\end{array}
$$

$\therefore$ From equation (i)

$$
R_{B}=W \cos \theta=10000 \times \frac{1}{2}=\mathbf{5 0 0 0} \text { Newtons Ans. }
$$

and

$$
P=W \sin \theta=\frac{10000 \times \sqrt{3}}{2}=8660 \text { newtons Ans. }
$$



Fig. 47. (b)

## b) Explain and elaborate the following

i) Parallelogram Law:

## ii) Varignon's Theorem:

iii) Trusses and frames:

## Q.No 3. Attempt any two of the following

a) A beam is supported and loaded by hinged support at $\mathbf{A}$ and roller support at $B$ as shown in the figure. Find the reactions at $A$ and $B$


Fig. 3.9
Solutioiz. Beam is hinged at $A\left(X_{A}, Y_{A}\right)$ and roller supported at $B\left(R_{B}\right)$. Forces about $C$ form a couple of magnitude $M_{C}=20(1+1)=40 \mathrm{kN}-\mathrm{m}$ acting anticlockwise and forces about $D$ forms a couple of magnitude $M_{D}=10$ ( 0.5 $+0.5)=10 \mathrm{kN}-\mathrm{m}$ acting clockwise. A force of 20 kN is acting at a distance
of 1 m from $E$. It is transferred to the point $E$ as a force of 20 kN couple of magnitude $20(1)=20 \mathrm{kN}-\mathrm{m}$ acting clockwise.

$$
\begin{array}{ll}
\Sigma \boldsymbol{F}_{x}=0: & X_{A}+20=0, X_{A}=-20 \mathrm{kN} \text { Ans. (change the assumed di } \\
\Sigma \boldsymbol{F}_{y}=0: & Y_{A}+R_{B}=0 \\
\Sigma M_{A}=0: & 40-10-20+R_{B}(12)=0 \\
& R_{B}=-\frac{10}{12}=-0.833 \mathrm{kN} \\
& R_{B}=0.833 \mathrm{kN} \text { (down). Ans. } \\
& Y_{A}=-R_{B}=-(-0.833) \\
& Y_{A}=0.833 \mathrm{kN} \text { (up). Ans. }
\end{array}
$$

b) Find the axial force in the member DE of the truss using the method of sections.


Fig. 9.11


Right 1 land
Portion

Fig. 9.12
Solution. First determine the reactions at the supports by considering the entire truss as a free-body. They are determined to be $R_{A}=2.5 \mathrm{kN}$ and $R_{C}=3.5 \mathrm{kN}$. To determine the force in the member $D E$ pass a section cutting the member $D E$ and any two other members of the truss so as to divide the truss into two separate portions. The total number of members cut should not exceed three.

There can be more than one way to pass a section (mn or op).
Consider the truss as cut by the section mn. The two portions of the truss are as shown in Fig. 9.12.

Assume and mark the directions of the forces in the cut members. The forces in the cut members can be assumed to act away from the joints. But, the directions of the axial forces assumed in a member in the two portions of the truss must be consistent with the principle of action and reaction. For example, if the force in the member $D E$ at the joint $D$ is shown to act from left to right then at the joint $E$ it must be shown to act from right to left (i.e. tension).

Consider now the equilibrium of the left hand portion of the truss. The three unknown forces acting on the portion of the truss are

$$
F_{D E}, F_{D B} \text { and } F_{A B}
$$

Write the equations of equilibrium.
Taking moments about $B$,

$$
\begin{aligned}
\Sigma M_{B}=0: \quad 2000\left(3 \sin 30^{\circ}\right)-R_{A}(3)+F_{D E}\left(3 \cos 30^{\circ}\right) & =0 \\
2000 \times 3 \times 0.5-3 R_{A}+F_{D E}(3 \times 0.866) & =0 \\
F_{D E} & =\frac{1500}{0.866} \\
F_{D E} & =1732 \mathrm{~N}(\mathrm{~T}) \quad \text { Ans. }
\end{aligned}
$$

c) How will you find out the resultant of two parallel forces acting in the same direction. Explain with neat diagram.

