Department Civil Engineering, IIT Bombay
CE 102 Engineering Mechanics – Quiz No.1

Date: January 31, 2006 **Max. Marks: 10+10**

Note: Answer both questions. Assume suitable data, if required, and state the same clearly. Wherever required, consider the acceleration due to gravity g = 10 m/s^2.

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1. The worm-gear speed reducer shown in **Fig. 1** weighs **75 N**; the center of gravity is located on the *x*-axis at $x = 8$ **cm**. Replace the weight and couples shown by a wrench. Specify the axis, pitch and point of intersection with the *x*-z plane. **(10)**

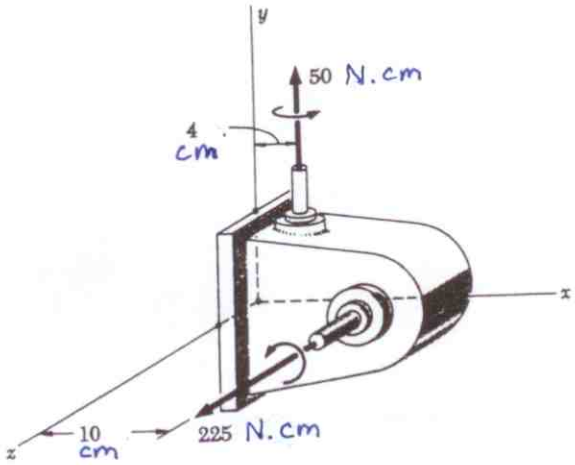

Fig. 1

2. The flat plate, shown in **Fig. 2,** seals a triangular opening in the vertical wall of a tank of liquid of unit weight $\gamma = 10$ **kN.m**$^{-3}$. The plate is hinged about the upper edge ***O*** of the triangle. Determine the force ***P*** required to hold the gate in a closed position against the pressure of the liquid. Take $h = 1$ **m,** $a = 2$ **m,** $b = 3$ **m.** **(10)**

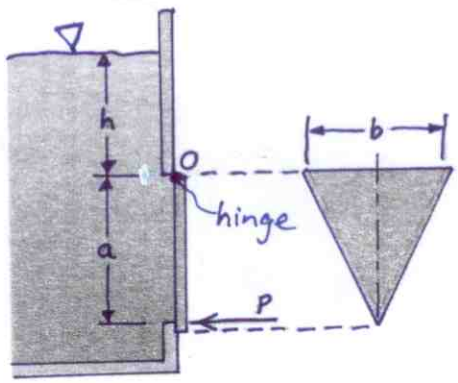

Fig. 2

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P.1

$\underline{R} = -75\underline{j}$

$\underline{M}_0^R = 225\underline{k} + 50\underline{j} - 75*8\underline{k} = -375\underline{k} + 50\underline{j}$

$p = \dfrac{\underline{R}\cdot\underline{M}_0^R}{R^2} = \dfrac{-75*50}{75^2} = -\dfrac{2}{3}$ ◀

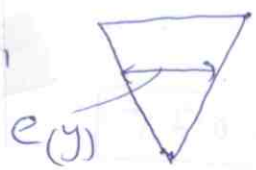
$\left(-\frac{2}{3}\right)(-75\underline{j}) + (x\underline{i} + z\underline{k}) \times (-75\underline{j}) = -375\underline{k} + 50\underline{j}$

$\Rightarrow -75x = -375 \Rightarrow x = 5$

$z = 0$

Axis is y-axis thru point $(5, 0, 0)$ ◀

P2.



$e(y) = py + q$

$b = p(0) + q \rightarrow q = b$

$= p(a) + q \rightarrow p = \dfrac{-q}{a} = \dfrac{-b}{a}$

$$Pa = \int_0^a y\, \rho g (y+h)\, e(y)\, dy = \rho g \int_0^a y(y+h)(py+q)\, dy$$

$$= \rho g \left[p\frac{y^4}{4} + (q+hp)\frac{y^3}{3} + hq\frac{y^2}{2} \right]_0^a$$

$$= \rho g \left[\left(\frac{-b}{a}\right)\left(\frac{a^4}{4}\right) + \left(b + h\left(\frac{-b}{a}\right)\right)\frac{a^3}{3} + hb\frac{a^2}{2} \right]$$

$$= \rho g \left[-\frac{ba^3}{4} + \frac{ba^3}{3} - \frac{hba^2}{3} + \frac{hba^2}{2} \right]$$

$$Pa = \rho g \left[\frac{ba^3}{12} + h\frac{ba^2}{6} \right] \Rightarrow P = \rho g \frac{ba}{6}\left(\frac{a}{2} + h\right)$$