Department Civil Engineering
Indian Institute of Technology Bombay

CE 102 Engineering Mechanics: QUIZ NO. – 1

Date: January 23, 2007 **Max. Marks: 10**

Note: Answer both questions. Assume suitable data, if required, and state the same clearly.

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1. A system of forces gives a resultant force $\overline{F}$ = **(10*i* – 6*j* + 4*k*) kN** passing through a point with coordinate ***x* = 3 m, *y* = 4 m and *z* = 6 m,** and a couple moment $\overline{C}$ = **(2*i* + 10*j*) kN.m**. Reduce this system to an equivalent wrench. Find the point of intersection of this wrench with ***x*-*z*** plane. **(5)**

2. A uniform rectangular gate of weight ***W***, height ***r***, and length ***b*** is hinged at point ***A*** as shown in **Fig. A**. Denoting the specific weight of the fluid by γ, determine the required angle θ if the gate is to permit flow when ***d* = *r***. **(5)**

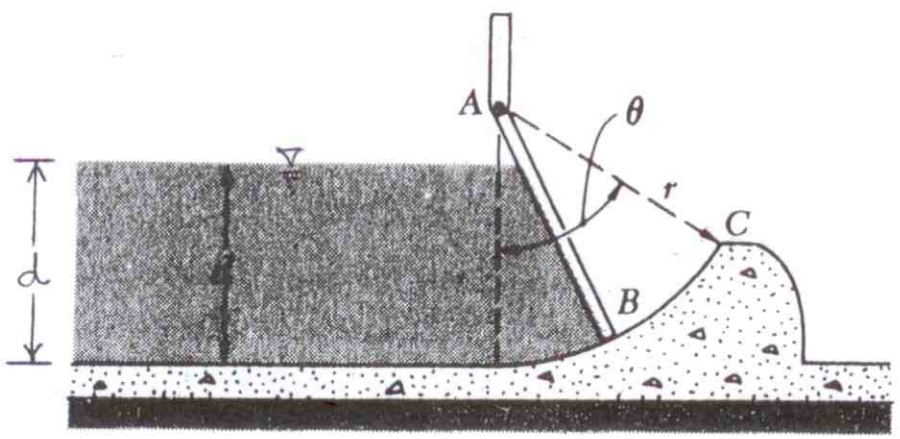

Fig. A

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CE102 – Quiz I Solution 2007.

(1) $\underline{R} = 10\underline{i} - 6\underline{j} + 4\underline{k}$ ◀

$\underline{M} = 2\underline{i} + 10\underline{j} + (3\underline{i} + 4\underline{j} + 6\underline{k}) \times (10\underline{i} - 6\underline{j} + 4\underline{k})$

$= 54\underline{i} + 58\underline{j} - 58\underline{k}$

$p = \dfrac{\underline{M} \cdot \underline{R}}{R^2} = -\dfrac{40}{152}$ ◀

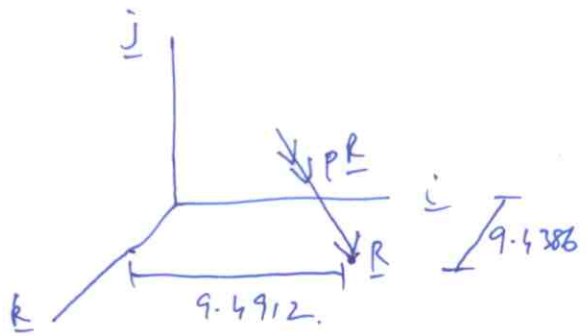
$\underline{M} = p\underline{R} + (\underline{r} \times \underline{R}) = \left(-\dfrac{40}{152}\right)(10\underline{i} - 6\underline{j} + 4\underline{k})$

$+ (x\underline{i} + z\underline{k}) \times (10\underline{i} - 6\underline{j} + 4\underline{k})$

$\underline{i}$: $54 = -\dfrac{400}{152} + 6z \Rightarrow z = 9.4386\ m$ ◀

$\underline{j}$: $58 = \dfrac{240}{152} - 4x + 10z$ ⟵ identically satisfied.

$\underline{k}$: $-58 = -\dfrac{160}{152} - 6x \Rightarrow x = 9.4912\ m$ ◀



(2) $\Sigma M_A = 0 \Rightarrow W\dfrac{r}{2}\sin\theta - \left[\dfrac{1}{2}(r)(\gamma r\cos\theta)\right](b)\left(\dfrac{2}{3}r\right) = 0$

$\Rightarrow \theta = \tan^{-1}\left\{\dfrac{2}{3}\left(\dfrac{\gamma r^2 b}{W}\right)\right\}$.