Department of Civil Engineering, IIT Bombay
CE 102 Engineering Mechanics – Quiz - I

Date: Feb 6, 2008 **Max. Marks: 20**

Each question worth 10 marks

Note: State clearly all assumptions you have made, if any. Draw clear Free body Diagram(s). If you make multiple attempts, cancel out the one(s) you don't want to be graded. Only the first non-cancelled one encountered will be graded. .

Time: 1 hour

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1. A hollow steel cone with internal dimensions as shown in Fig. 1 has a pinhole at the top. The cone is filled with water. What is the minimum weight of the cone which will prevent the water from up-lifting the cone and flowing out? Use density of water as 1000 kg/m^3 and acceleration due to gravity g = 10 m/s^2.

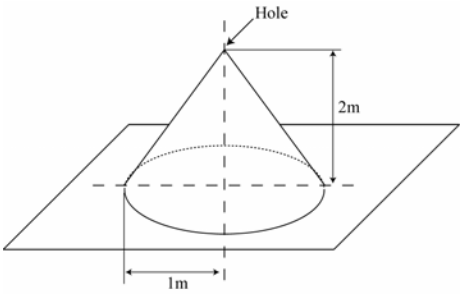


Fig. 1

2. Determine the reaction at *A*, the force in bar *DE*, and the force in the bar *BF* due to the action of the loads *P* and *Q* applied to the crane, as shown in Fig. 2. Clearly state the nature (i.e., tensile or compressive) of the forces in members *DE* and *BF*. Assume that *P* = 500kN, *Q* = 300kN, *a* = 6m.

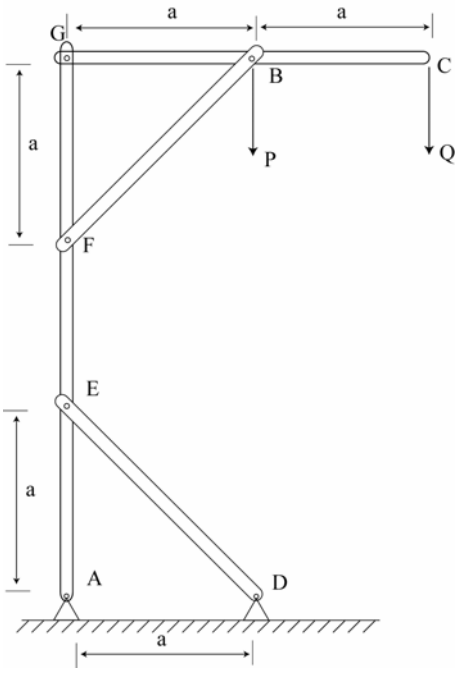
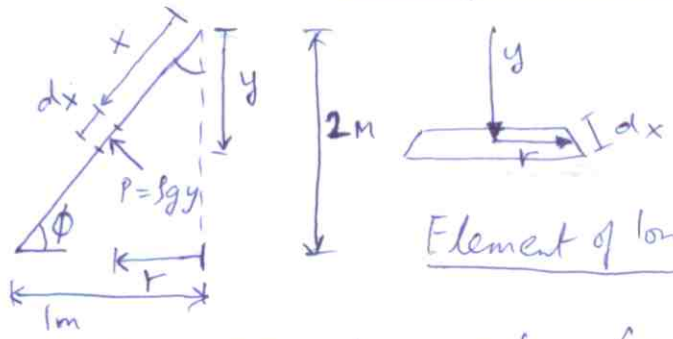


Fig. 2

CE-102 Quiz I Spring 2008 Solutions.

P-1



Element of lowest order.

$$dF_y = \rho g y \, 2\pi r \, dx \cos\phi \quad \left(\equiv \int_0^{2\pi} \rho g y \, r \, d\theta \, dx \cos\phi\right)$$

$$r = y \tan(90-\phi)$$

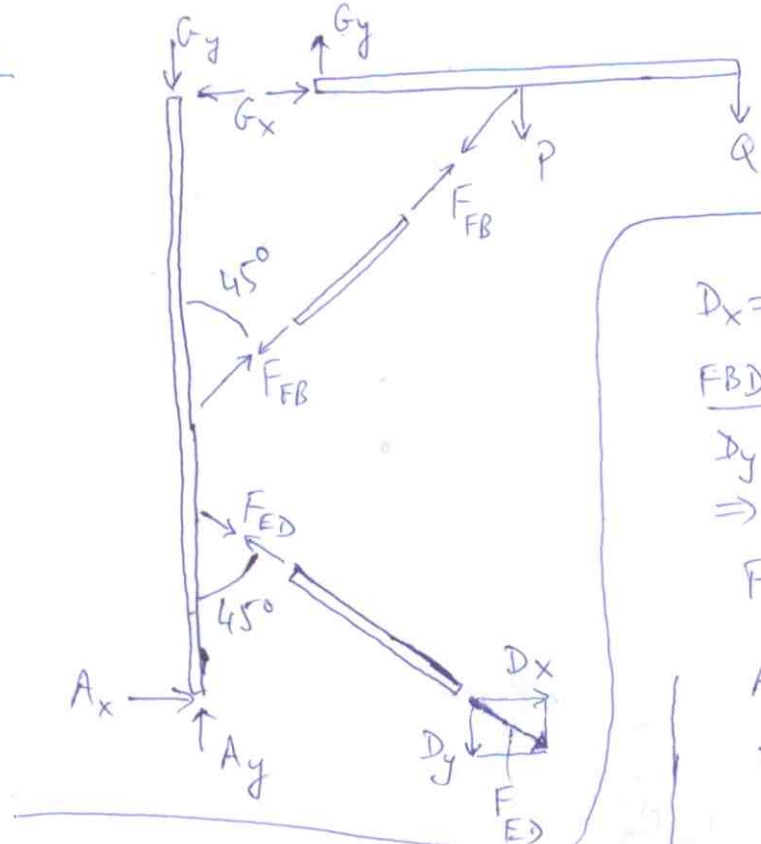
$$x = y/\sin\phi$$

$$F_y = \int dF_y = 2\pi\rho g \frac{\cos\phi \tan(90-\phi)}{\sin\phi} \int_0^2 y^2 dy = 2\pi\rho g \frac{2^3}{3}\cot^2\phi$$

$$= 2\pi(1000)(10)\frac{2^3}{3}\frac{1}{2^2} = 41888\ \text{N}.$$

$W = F_y = 41888$ N for no up-lifting of crane. ◀

P-2



FBD of horizontal member

$$\Sigma M_C = 0 = \frac{F_{FB}}{\sqrt{2}} a + Pa + 2Qa = 0$$

$$\Rightarrow F_{FB} = 1555\ (C) \blacktriangleleft$$

$D_x = D_y$

FBD of whole crane:

$$D_y a + (P+2Q)\, a = 0$$

$$\Rightarrow D_y = -(500 + 2\times 300) = -1100$$

$$F_{ED} = D_y\sqrt{2} = 1555\ (C)\ \text{N} \blacktriangleleft$$

$$A_y - D_y = P + Q$$

$$\Rightarrow A_y = 800 - 1100 = -300$$

$$A_x + D_x = 0$$

$$\Rightarrow A_x = 1100$$

$$A = \sqrt{A_x^2 + A_y^2} = 1140\ \text{N} \blacktriangleleft$$