(Spring 2009, March 5, Thursday)

MMAE 201 MECHANICS OF SOLIDS I

MIDTERM EXAM – I

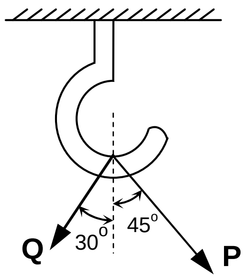
Q1 – A Servo-hydraulic testing machine has a loading capacity of 50 kips (kilopounds). What is the maximum load it can apply in N (Newton)? **[10 pts]**

1 lb is the weight of "standard pound" which is 0.4536 kg.

$$1\ lb = (0.4536\ kg)\cdot(9.807\ m/s^2) = 4.448\ N$$

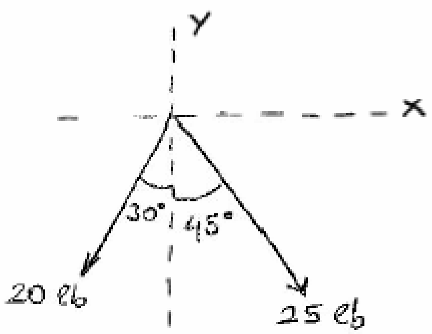
$$50\ kips = 50{,}000\ lb \cdot \frac{4.448\ N}{1\ lb} = 222{,}400\ N = \boxed{222.4\ kN}\ *$$

Q2 – Two forces are applied to a hook support as shown in Figure.



(a) Find the magnitude and direction of resultant force knowing that the magnitude of **P** is 25 lb, and the magnitude of **Q** is 20 lb. **[15 pts]**

(b) Find the net horizontal force acting on the hook and its direction. **[10 pts]**

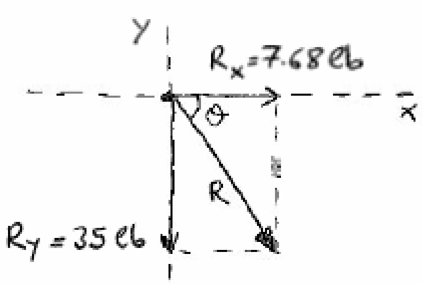


$$R_x = \sum F_x = -20\cdot\sin 30^\circ + 25\cdot\sin 45^\circ$$

$$= \boxed{7.68\ lb}\ *$$ net horizontal force acting in positive x-direction.

$$R_y = \sum F_y = -20\cdot\cos 30^\circ - 25\cdot\cos 45^\circ$$

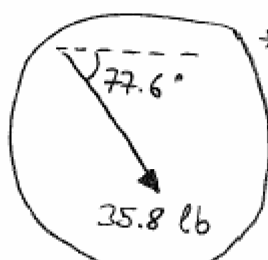
$$= \boxed{-35\ lb}$$



Resultant force:

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{7.68^2 + 35^2} = \boxed{35.8\ lb}\ *$$

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = 77.6^\circ$$



* resultant force & its direction!

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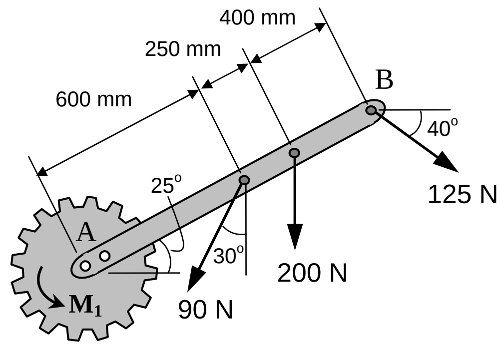
Q3 – The gear shown below is rigidly attached to arm AB. If the forces and couple shown can be reduced to a single equivalent force at A, determine

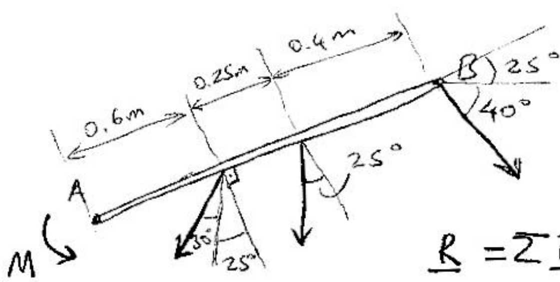
(a) the magnitude of the couple $\mathbf{M_1}$ **[15 points].**

(b) the equivalent force and its direction **[15 points].**



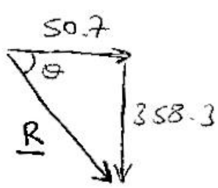
If the system of forces applied on the rigid body can be reduced to a single equivalent force at A, the resultant couple acting at A should be zero;

$$+\circlearrowleft \Sigma M_A = 0 \rightarrow M - (0.6m)\cdot 90\cos 55° - (0.85m)\,200\cos 25° - (1.25m)\cdot 125\sin 65° = 0$$



$$\Rightarrow \boxed{M = 326.6\ N.m} *$$

$$\underline{R} = \Sigma \underline{F} = (-90\sin 30° + 125\cos 40°)\,\hat{\imath} + (-90\cos 30° - 200 - 125\cdot\sin 40°)\,\hat{\jmath}$$



$$\underline{R} = 50.7\,\hat{\imath} - 358.3\,\hat{\jmath} \quad [N]$$

$$\Rightarrow R = \sqrt{50.7^2 + 358.3^2} = 362N$$

$$\theta = \tan^{-1}\left(\frac{358.3}{50.7}\right) = 81.9°$$

$$\Rightarrow \boxed{R = 362N} * \quad \theta = 81.9°$$

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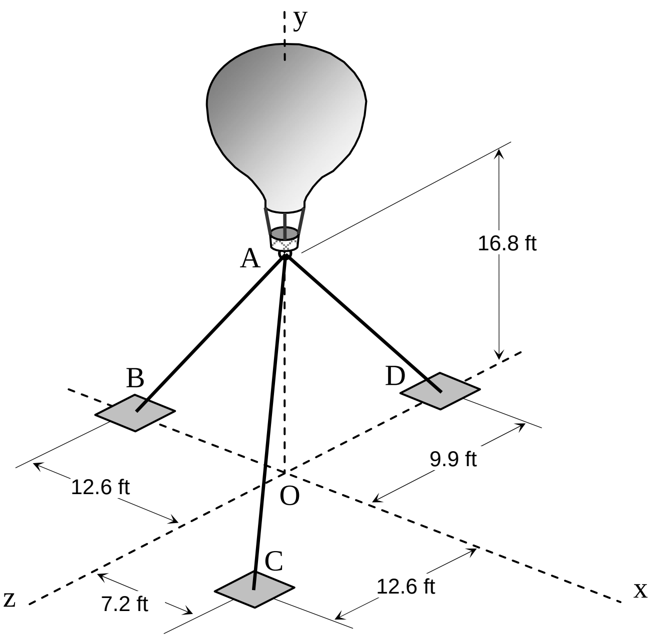
Q4 – Three cables are used to fasten a balloon as shown. Knowing that the tension in cable AB is **60 lb** determine

(a) the tension in other cables **[20 points],**

(b) the vertical force **P** exerted by the balloon at A **[15 points].**



$$\underline{T}_{AB} = T_{AB}\,\underline{\lambda}_{AB} = 60\left(\frac{-12.6\,\hat{i} - 16.8\,\hat{j}}{\sqrt{12.6^2+16.8^2}}\right) = -36\,\hat{i} - 48\,\hat{j} \quad [lb]$$

$$\underline{T}_{AD} = T_{AD}\,\underline{\lambda}_{AD} = T_{AD}\left(\frac{-16.8\,\hat{j} - 9.9\,\hat{k}}{\sqrt{16.8^2+9.9^2}}\right) = T_{AD}\left(-0.862\,\hat{j} - 0.508\,\hat{k}\right) \quad [lb]$$

$$\underline{T}_{AC} = T_{AC}\,\underline{\lambda}_{AC} = T_{AC}\left(\frac{7.2\,\hat{i} - 16.8\,\hat{j} + 12.6\,\hat{k}}{\sqrt{7.2^2+16.8^2+12.6^2}}\right) = T_{AC}\left(0.324\,\hat{i} - 0.757\,\hat{j} + 0.568\,\hat{k}\right) \quad [lb]$$

$$\underline{P} = P\,\hat{j} \quad [lb]$$

Equilibrium of point A;

$$\Sigma F_x = 0 \rightarrow -36 + 0.324\,T_{AC} = 0 \rightarrow \boxed{T_{AC} = 111.1\ lb}$$

$$\Sigma F_z = 0 \rightarrow -0.508\,T_{AD} + 0.568\,T_{AC} = 0 \rightarrow \boxed{T_{AD} = 124.2\ lb}$$

$$\Sigma F_y = 0 \rightarrow -48 - 0.862\,T_{AD} - 0.757\,T_{AC} + P = 0 \rightarrow \boxed{P = 239.2\ lb}\ *$$