Engineering Mechanics
AGE 2330

Lect 9: MT Review

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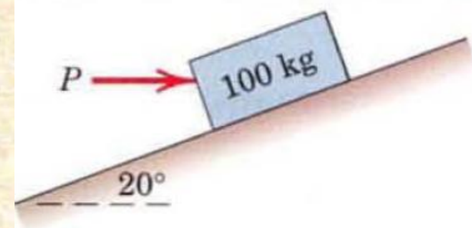
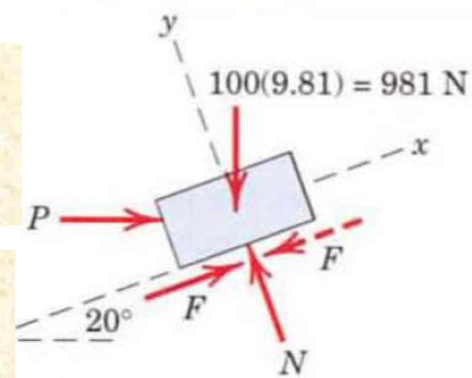
Determine the magnitude and direction of the friction force acting on the 100-kg block shown if, first, $P = 500$ N and, second, $P = 100$ N. The coefficient of static friction is 0.20, and the coefficient of kinetic friction is 0.17. The forces are applied with the block initially at rest.



Solution. There is no way of telling from the statement of the problem whether the block will remain in equilibrium or whether it will begin to slip following the application of P. It is therefore necessary that we make an assumption, so we will take the friction force to be up the plane, as shown by the solid arrow. From the free-body diagram a balance of forces in both x- and y-directions gives

$[\Sigma F_x = 0]$ $$P \cos 20° + F - 981 \sin 20° = 0$$

$[\Sigma F_y = 0]$ $$N - P \sin 20° - 981 \cos 20° = 0$$



Case I. $P = 500$ N

Substitution into the first of the two equations gives

$$F = -134.3 \text{ N}$$

$$N = 1093 \text{ N}$$

The maximum static friction force which the surfaces can support is then

$[F_{max} = \mu_s N]$ $$F_{max} = 0.20(1093) = 219 \text{ N}$$

Since this force is greater than that required for equilibrium, we conclude that the assumption of equilibrium was correct. The answer is, then,

$$F = 134.3 \text{ N down the plane} \qquad \textit{Ans.}$$

Case II. $P = 100 \text{ N}$

Substitution into the two equilibrium equations gives

$$F = 242 \text{ N} \qquad N = 956 \text{ N}$$

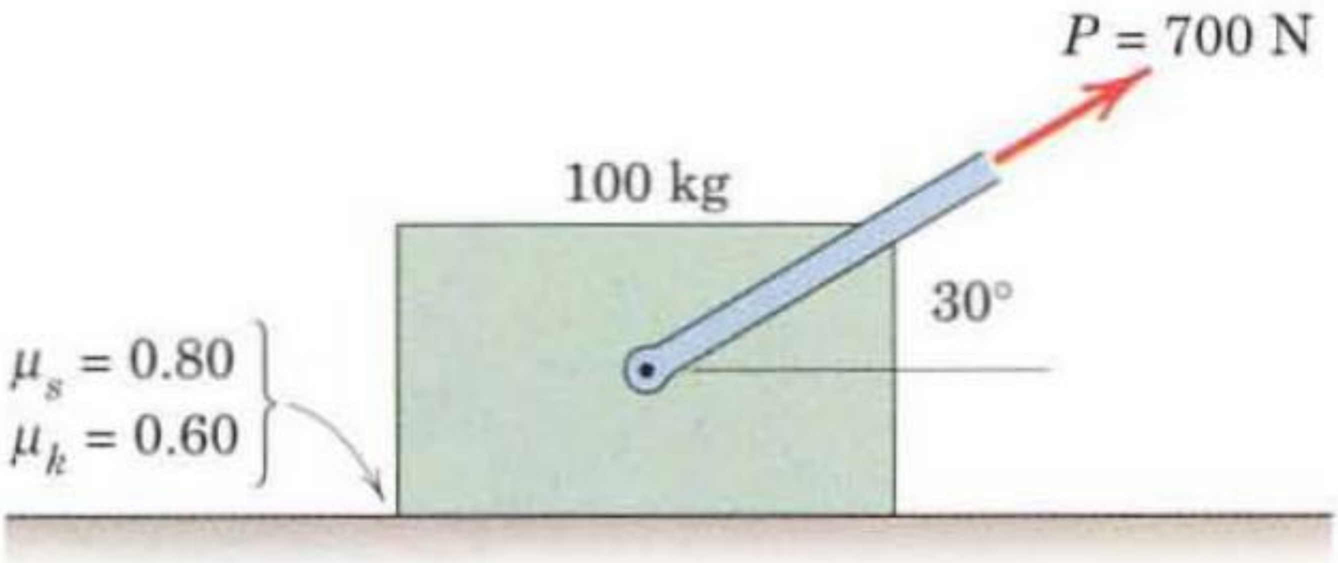
But the maximum possible static friction force is

$$[F_{max} = \mu_s N] \qquad F_{max} = 0.20(956) = 191.2 \text{ N}$$

It follows that 242 N of friction cannot be supported. Therefore, equilibrium cannot exist, and we obtain the correct value of the friction force by using the kinetic coefficient of friction accompanying the motion down the plane. Hence, the answer is

$$[F_k = \mu_k N] \qquad F = 0.17(956) = 162.5 \text{ N up the plane} \qquad \textit{Ans.}$$

The 700-N force is applied to the 100-kg block, which is stationary before the force is applied. Determine the magnitude and direction of the friction force F exerted by the horizontal surface on the block.



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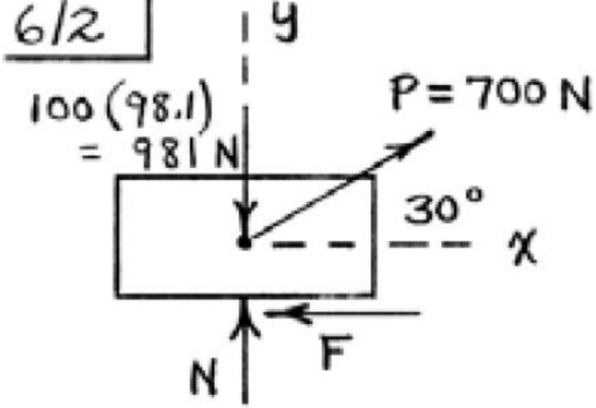


Assume equilibrium.

$\Sigma F_x = 0: \quad 700 \cos 30° - F = 0, \quad F = 606 \text{ N}$

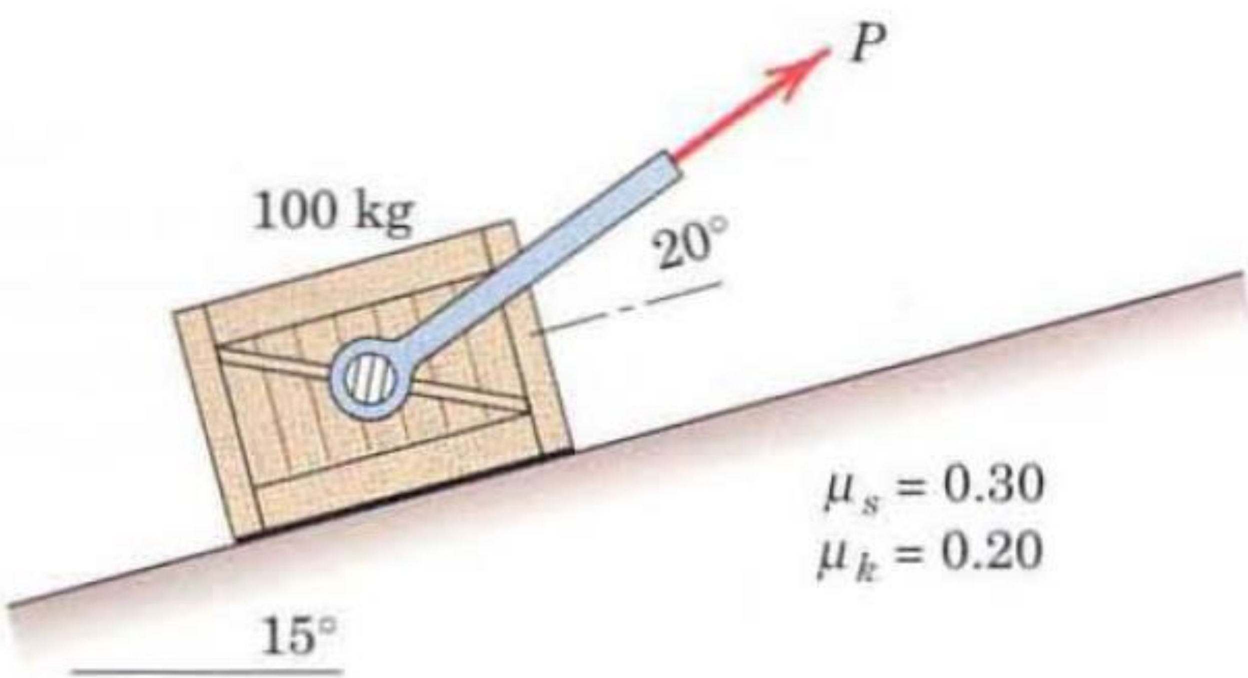
$\Sigma F_y = 0: \quad N - 981 + 700 \sin 30° = 0, \quad N = 631 \text{ N}$

$F_{max} = \mu_s N = 0.8 (631) = 505 \text{ N} < F = 606 \text{ N}$

Assumption invalid, motion occurs.

$F = \mu_k N = 0.6 (631) = \underline{379 \text{ N}}$

The coefficients of static and kinetic friction between the 100-kg block and the inclined plane are 0.30 and 0.20, respectively. Determine (*a*) the friction force F acting on the block when P is applied with a magnitude of 200 N to the block at rest, (*b*) the force P required to initiate motion up the incline from rest, and (*c*) the friction force F acting on the block if P = 600 N.



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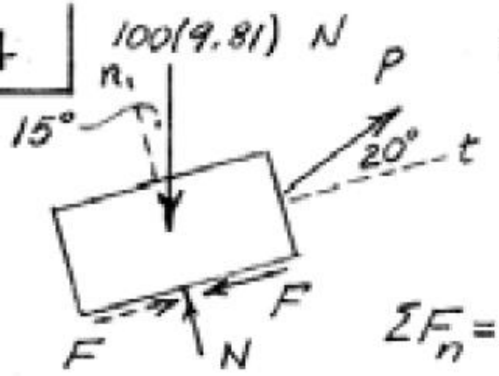


(a) Assume equilibrium

$\Sigma F_t = 0$; $200 \cos 20° + F_{up} - 981 \sin 15° = 0$

$\underline{F = 66.0\ N}$

$\Sigma F_n = 0$; $N + 200 \sin 20° - 981 \cos 15° = 0$

$N = 879\ N$

& $F_{s_{max}} = 0.3(879) = 264\ N > 66.0\ N$ so equil. assumpt. OK

(b) $F_{dwn} = \mu_s N$; $\Sigma F_t = 0$; $P \cos 20° - 981 \sin 15° - 0.3N = 0$

$\Sigma F_n = 0$; $N + P \sin 20° - 981 \cos 15° = 0$

Solve & get $\underline{P = 516\ N}$

(c) Assume slipping up plane with $F_{dwn} = \mu_K N$

$\Sigma F_n = 0$; $600 \sin 20° + N - 981 \cos 15° = 0$, $N = 742\ N$

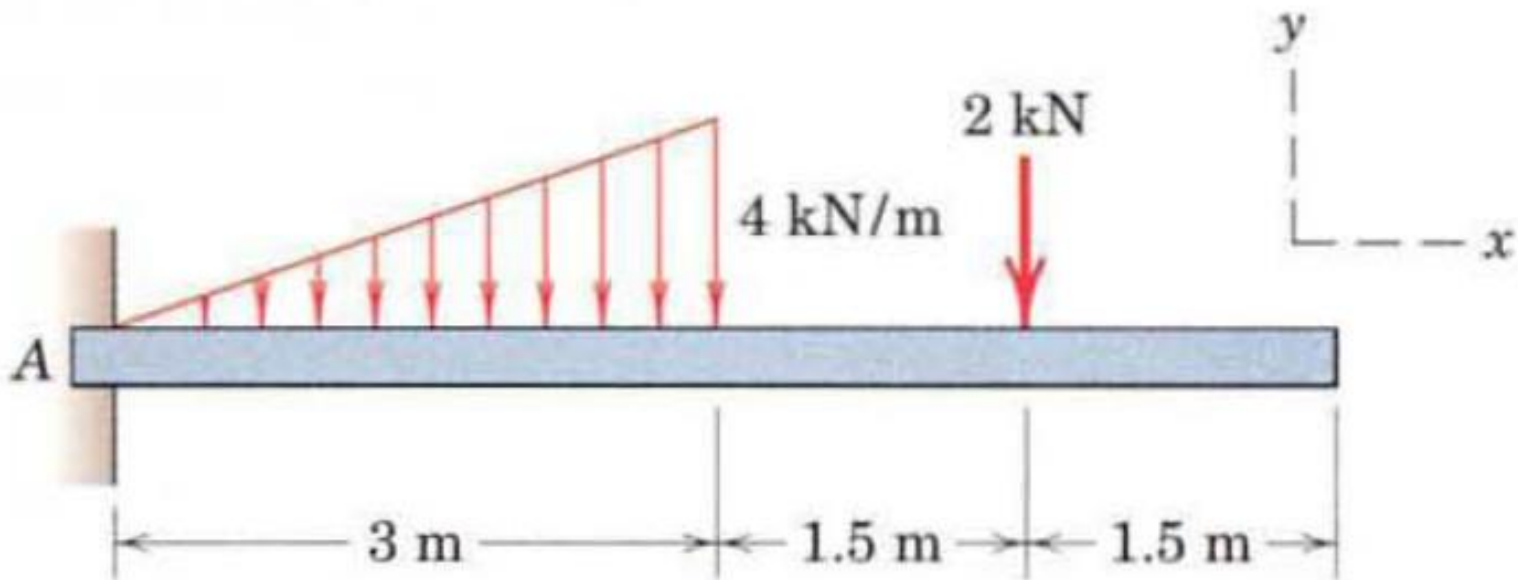
$F = 0.2(742) = \underline{148.5\ N}$

$\Sigma F_t = 600 \cos 20° - 981 \sin 15° - 148.5 = 161.4\ N > 0$

so block moves up plane as assumed

5/97 Determine the reactions at A for the cantilever beam subjected to the distributed and concentrated loads.

Ans. $A_x = 0$, $A_y = 8$ kN, $M_A = 21$ kN·m



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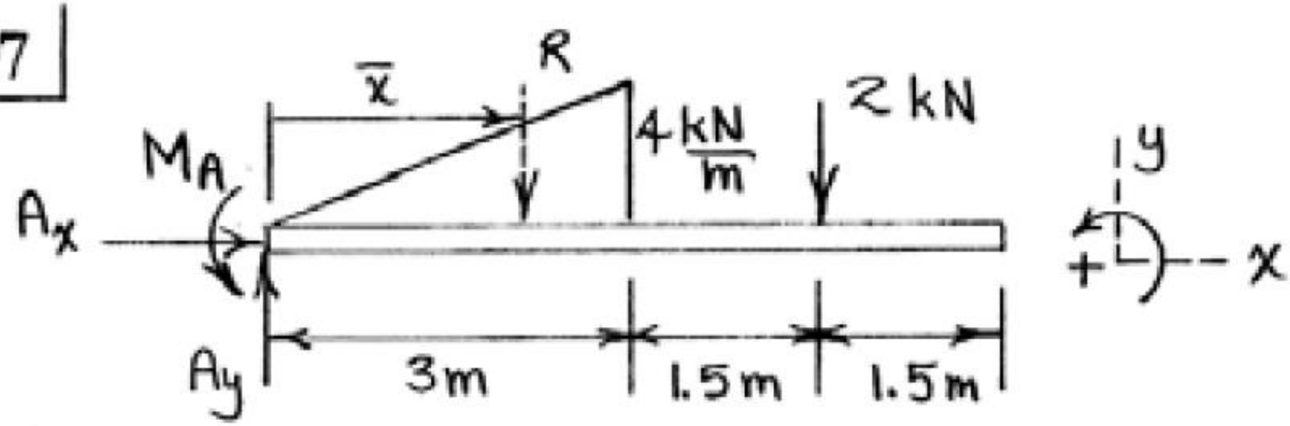


$R = \frac{1}{2}(3)(4) = 6$ kN @ $\bar{x} = \frac{2}{3}(3) = 2$ m

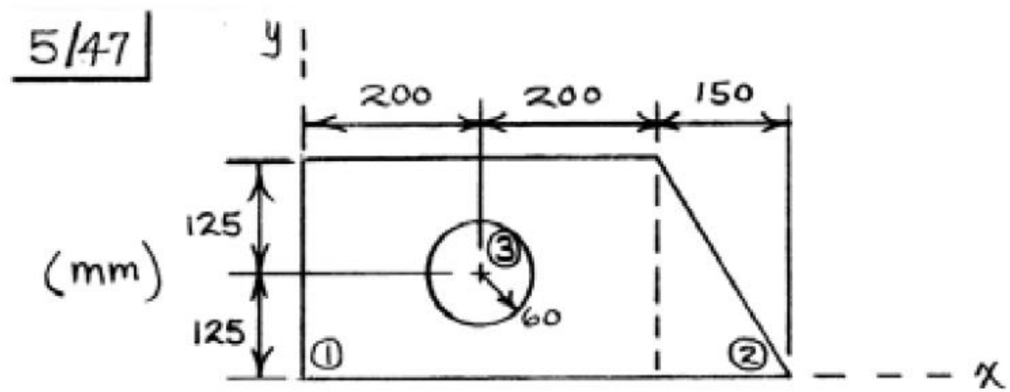
$\Sigma M_A = 0: \ M_A - 6(2) - 2(4.5) = 0, \quad \underline{M_A = 21 \text{ kN·m}}$

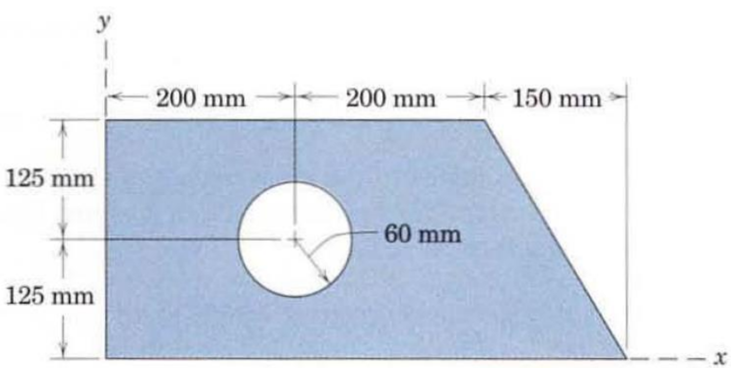
$\Sigma F_y = 0: \ A_y - 6 - 2 = 0, \quad \underline{A_y = 8 \text{ kN}}$

$\Sigma F_x = 0: \ \underline{A_x = 0}$

5/47 Determine the coordinates of the centroid of the shaded area.

Ans. $\overline{X} = 244$ mm, $\overline{Y} = 117.7$ mm



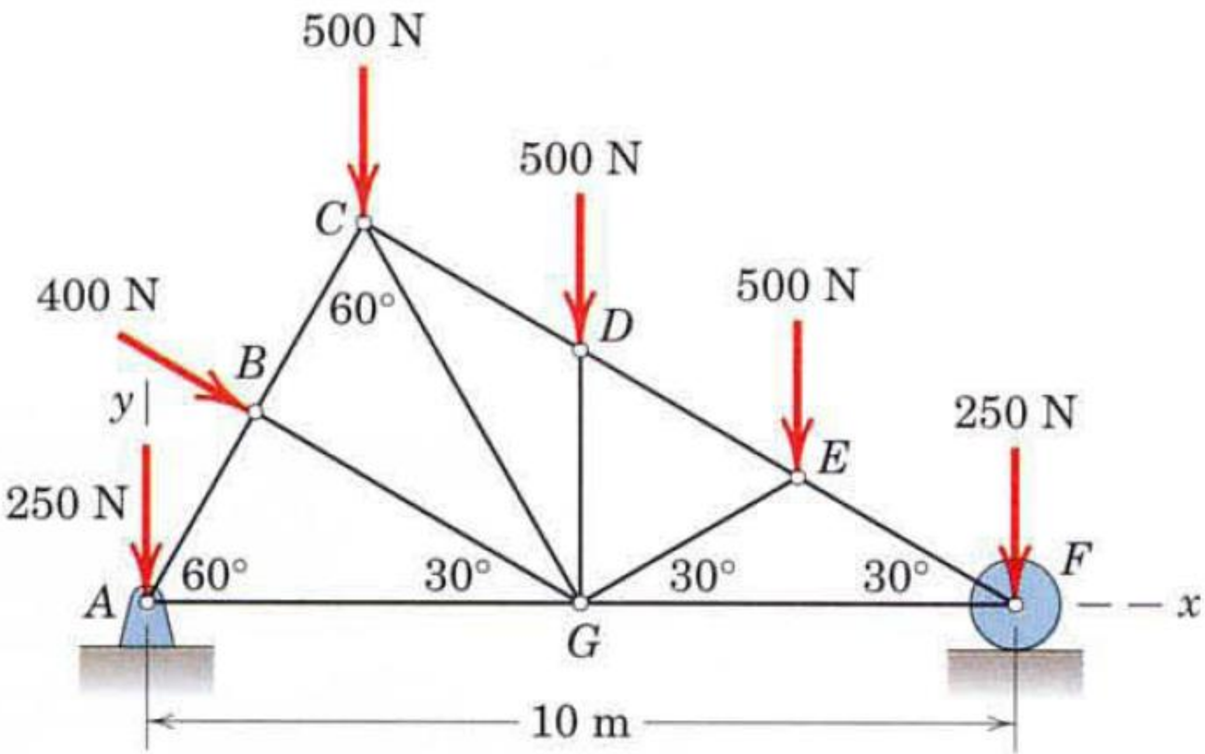


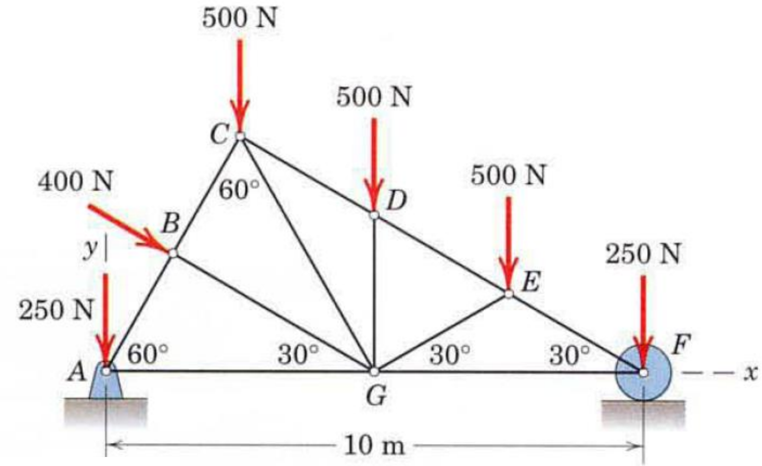
Comp.	A mm^2	$\bar{x}$ mm	$\bar{y}$ mm	$A\bar{x}$ mm^3	$A\bar{y}$ mm^3
Rect. 1	$100(10^3)$	200	125	$20(10^6)$	$12.50(10^6)$
Triangle 2	$18.75(10^3)$	450	250/3	$8.44(10^6)$	$1.563(10^6)$
Circle 3	$-11.31(10^3)$	200	125	$-2.26(10^6)$	$-1.414(10^6)$
Totals	$107.4(10^3)$			$26.2(10^6)$	$12.65(10^6)$

$$\overline{X} = \frac{\Sigma A\bar{x}}{\Sigma A} = \frac{26.2(10^6)}{107.4(10^3)} = \underline{244 \text{ mm}}$$

$$\overline{Y} = \frac{\Sigma A\bar{y}}{\Sigma A} = \frac{12.65(10^6)}{107.4(10^3)} = \underline{117.7 \text{ mm}}$$

3/44 Determine the external reactions at A and F for the roof truss loaded as shown. The vertical loads represent the effect of the supported roofing materials, while the 400-N force represents a wind load.





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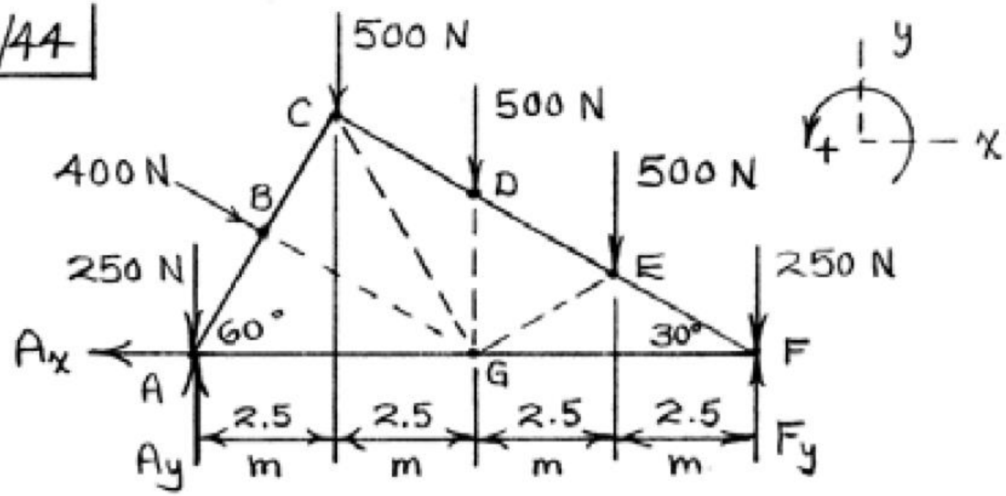
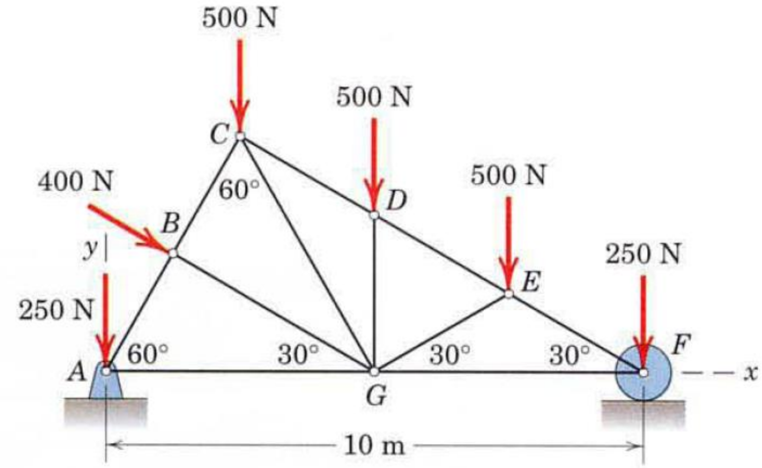


$\Sigma F_x = 0: \ -A_x + 400\cos 30° = 0, \ \underline{A_x = 346 \text{ N}}$

$\Sigma M_A = 0: \ 400\left(\frac{10}{4}\right) + 500(2.5) + 500(5)$

$+ 500(7.5) + 250(10) - 10F_y = 0$

$\underline{F_y = 1100 \text{ N}}$



$$\Sigma F_y = 0: -250 - 400 \sin 30° - 500(3) - 250$$

$$+ 1100 + A_y = 0, \qquad \underline{A_y = 1100 \text{ N}}$$