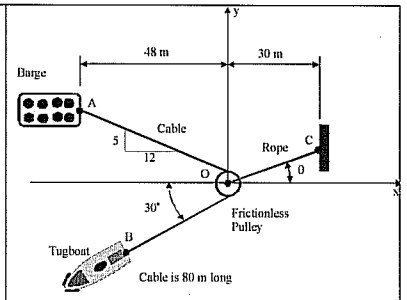
Engineering Statics
Assignment #1 SOLUTION

1) A tugboat is pulling a barge with a *80 m* long cable in the configuration shown in the figure. The cable is attached to the barge at *A* and wraps around a frictionless pulley and is attached to the tugboat at *B*. (Neglect the radius of the pulley.) The pulley is attached to the dock by the rope *OC*. The cable breaks when the tension in the cable reaches *1000N*.

Determine the tension in the rope *OC* and the angle θ at the instant the cable breaks using,

a) The graphical method (state the scale that you are using),

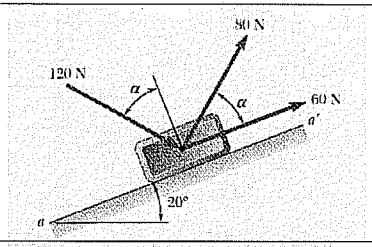
b) Trigonometry method (sine and/or cosine rules)



1) Knowing $\alpha = 40°$, determine the resultant of the three forces shown using:

a) The graphical method (state the scale that you are using),

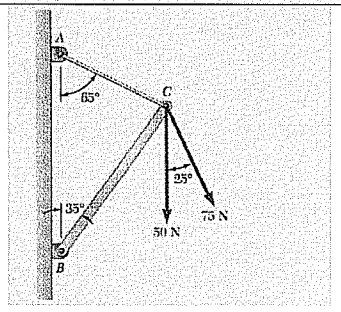
b) Trigonometry method (sine and/or cosine rules)



2) Determine the required tension in cable AC, knowing that the resultant of the three forces exerted at point C of the boom BC must be directed along BC, and the corresponding magnitude of the resultant using:

a) The graphical method (state the scale that you are using),

b) Trigonometry method (sine and/or cosine rules)



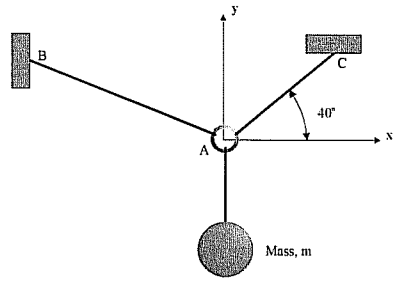
4) A mass, *m*, is suspended from a circular ring that is attached to supports by cables *AB* and *AC* as shown in the figure. The force in cable *AB* is 538.5 N.

Knowing that the point *A* is in equilibrium, determine the mass, *m* and the magnitude of the force in cable *AC* by each of the following methods:

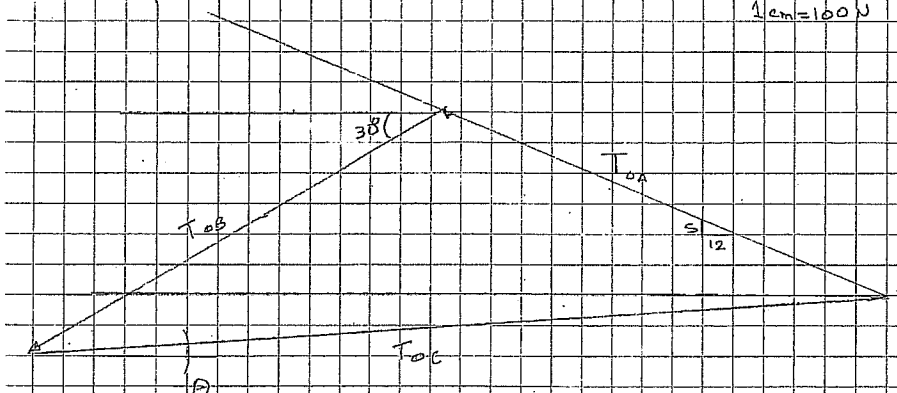
c) The graphical method (state the scale that you are using),

d) Trigonometry method (sine and/or cosine rules), and

Note: $g = 9.8$ m/sec^2
Also, the coordinates of B are (-500, 200) mm



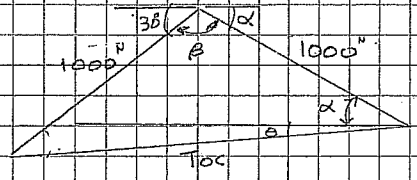
1) a) Graphical Solution



$T_{OC} = 1790$ N ◀

$\theta = 4°$ ◀

b) Trigonometry



$\tan\alpha = \frac{5}{12}$ $\alpha = 22.62°$

$\beta = 180 - 30° - 22.62$
$= 127.38°$

$T_{OC}^2 = 1000^2 + 1000^2 - 2(1000)(1000)\cos 127.38°$

$T_{OC} = 1792.82$ N ◀

$\frac{1000}{\sin(\alpha+\theta)} = \frac{T_{OC}}{\sin\beta}$

$\frac{1000}{\sin(22.62+\theta)} = \frac{1792.82}{\sin 127.38°}$

$\sin(22.62+\theta) = 0.4473$

$22.62+\theta = 26.32$

$\theta = 3.69°$ ◀

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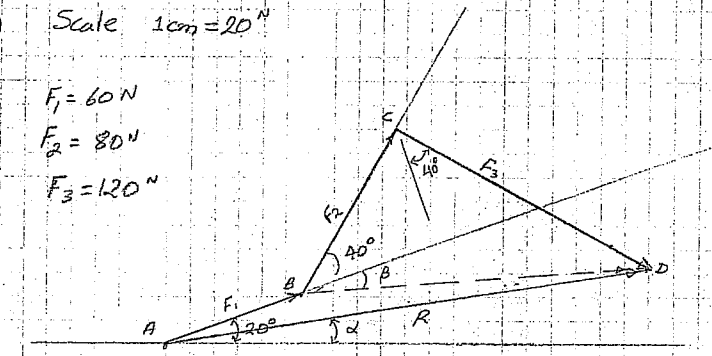
(#2)(a) Scale 1 cm = 20 N

$F_1 = 60$ N
$F_2 = 80$ N
$F_3 = 120$ N



AD = 10.2 cm ∴ R = 204 N ◀

α = 9° ◀

(b) From diagram in 1(a):

$\bar{R} = \bar{F}_1 + \bar{F}_2 + F_3$

Note $\bar{F}_2 + \bar{F}_3 = \bar{F}_{BD}$

Note ∠BCD = 90°

$\therefore F_{BD} = \sqrt{F_2^2 + F_3^2}$

$= \sqrt{80^2 + 120^2}$

$= 144.2$ N

$R^2 = F_1^2 + F_{BD}^2 - 2F_1F_{BD}\cos 163.7°$

$= 60^2 + 144.2^2 - 2(60)(144.2)\cos 163.7°$

$= 41002.1$

$R = 202.5$ N ◀

$\tan(40°+\beta) = \frac{F_3}{F_2} = \frac{120}{80}$

$\therefore 40°+\beta = 56.3°$

$\beta = 16.3°$

$\therefore \angle ABD = 180° - \beta = 163.7°$

$\frac{F_{BD}}{\sin(20-\alpha)} = \frac{R}{\sin 163.7°}$

$\sin(20-\alpha) = 0.2000$

$\therefore \alpha = 8.5°$

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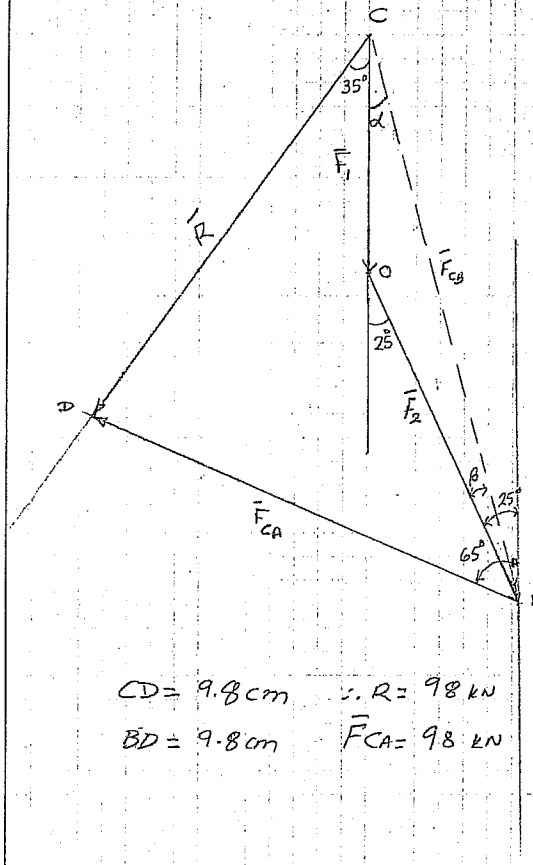
3) a) Scale 1 cm = 10 kN

$F_1 = 50$ kN

$F_2 = 75$ kN



CD = 9.8 cm ∴ R = 98 kN

BD = 9.8 cm $\bar{F}_{CA}$ = 98 kN

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3b) Using the diagram in 1(a).

$$\bar{F}_{CB} = \bar{F}_{CO} + \bar{F}_{OB}$$

$$\measuredangle COB = 180° - 25° = 155°$$

$$F_{CB}^2 = F_1^2 + F_2^2 - 2F_1F_2\cos 155°$$

$$= 50^2 + 75^2 - 2(50)(75)\cos 155°$$

$$= 14922.3$$

$$F_{CB} = 122.2 \text{ kN}$$

For triangle COB:

$$\frac{F_{CB}}{\sin 155°} = \frac{F_1}{\sin\beta} = \frac{F_2}{\sin\alpha}$$

$$\frac{122.2}{\sin 155°} = \frac{50}{\sin\beta} = \frac{75}{\sin\alpha}$$

$$\beta = 10° \qquad \alpha = 15°$$

$$\therefore \measuredangle DCB = 35° + \alpha = 50°$$

$$\measuredangle DBC = 65° - 25° + \beta = 50°$$

∴ Triangle DCB is an isosceles triangle and $R = F_{CA}$ and $\measuredangle CDB = 80°$

$$\frac{F_{CB}}{\sin 80°} = \frac{R}{\sin 50} = \frac{F_{CA}}{\sin 50}$$

$R = 95.0$ N and $F_{CA} = 95.0$ N

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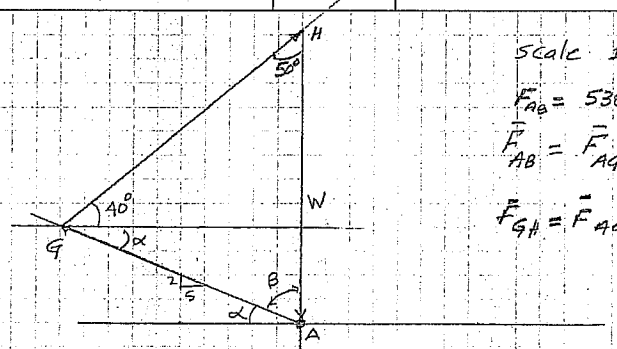
COURSE ENG 1440 | SECTION | DATE | PROBLEM 4 | SHEET OF

4(a)



Scale 1 cm = 100 N

$F_{AB} = 538.5\ N$

$\bar{F}_{AB} = \bar{F}_{AG}$ (AB and AG indicate direction. In this case, both forces are in the same direction. The same reasoning GH & AC and HA & W

$GH = 6.4\ cm \quad \therefore F_{GH} = 640\ N = F_{AC}$ ◀

$HA = 6.1\ cm \quad \therefore W = 610\ N. \quad \therefore m = 62.2\ kg$ ◀

(b) From the diagram above:

$$\tan\alpha = \frac{2}{5} \qquad \alpha = 21.8°$$

$$\beta = 90 - 21.8° = 68.2°$$

$$\measuredangle AGH = 40 + \alpha = 61.8°$$

$$\frac{538.5}{\sin 50} = \frac{F_{GH}}{\sin 68.2°} = \frac{W}{\sin 61.8}$$

$F_{GH} = 652.7\ N = F_{AC}$ ◀

$W = 619.5\ N \quad \therefore m = 63.2\ kg$ ◀