Concordia UNIVERSITY

Faculty of Engineering and Computer Science

ENGR 242/2 X Statics Fall 2005

Class Test (Oct 7, 2005)

Instructions:

(a) Write on both sides of the test. There is an extra sheet at the end. If you need extra papers to write, please ask the test supervisor.
(b) Answer all three questions.
(c) Scientific calculator is permitted
(d) Books, notes and programmable calculator are not permitted
(e) Keep your Student ID available.
(f) There are 5 (five) pages in this test.
(g) If there is any data missing, make a reasonable assumption with sufficient explanation

Name (print) _____

Student ID _____

Signature _____

Problem 1

Three forces are applied to lift the block as shown in Fig. 1. Knowing that P=75 N and $\alpha = 50^0$, determine:

(a) The resultant (magnitude and direction) of the three forces using **trigonometry** 20

(b) Resolve the resultant in x and y components 10 (30 marks)

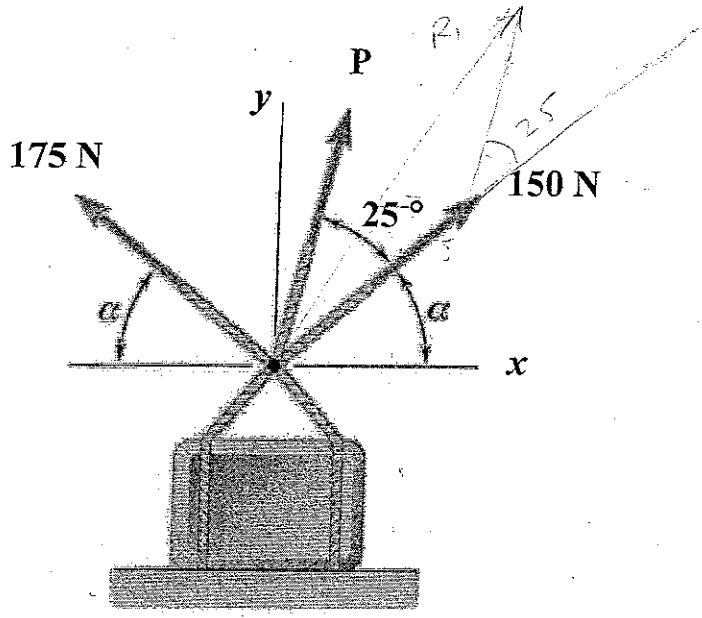
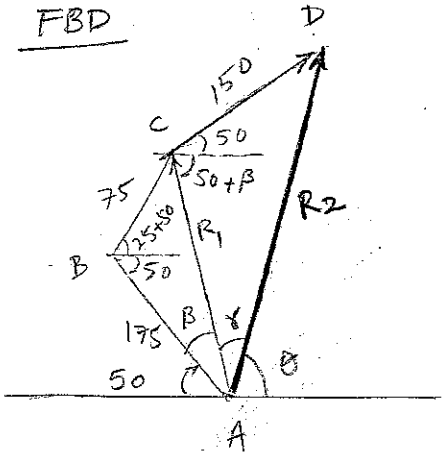


Fig. 1

(a)

FBD



③

In triangle ABC

Angle $B = 50+25+50 = 125^\circ$ ①

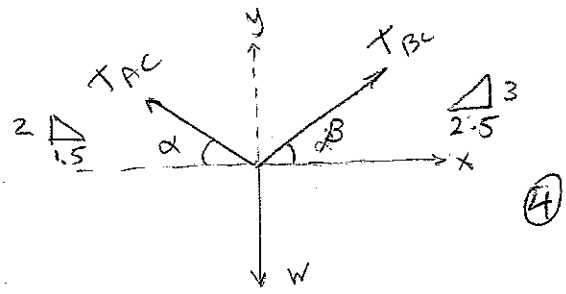
$R_1^2 = 175^2 + 75^2 - 2(75)(175)\cos(125)$ ②

$\rightarrow R_1 = 226.5$ N ①

$\frac{R_1}{\sin 125} = \frac{75}{\sin\beta}$ ① $\rightarrow \sin\beta = \frac{75}{226.5}\sin 125 = 0.271$ ② $\rightarrow \beta = 15.74^\circ$ ①

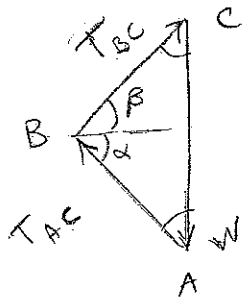
triangle ACD $\rightarrow$ Angle $C = 50+50+15.74 = 115.74^\circ$ ①

Alternative method



④

FBD



②

$\tan\alpha = \frac{2}{1.5} \rightarrow \alpha = 53.13^\circ$ ②

$\tan\beta = \frac{3}{2.5} \rightarrow \beta = 50.19^\circ$ ②

Angle $B = \alpha + \beta = 53.13 + 50.19 = 103.34^\circ$ ②

Angle $A = 90 - \alpha = 90 - 53.13 = 36.87^\circ$ ②

Angle $C = 90 - \beta = 90 - 50.19 = 39.81^\circ$ ②

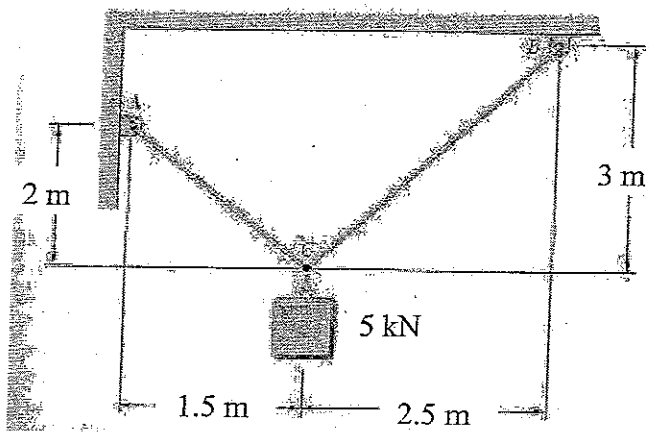
$$\frac{T_{AC}}{\sin C} = \frac{T_{BC}}{\sin A} = \frac{W}{\sin B} = \frac{5}{\sin 103.34}$$ ②

$$\rightarrow T_{AC} = 5\,\frac{\sin C}{\sin 103.34} = 5\,\frac{\sin 39.81}{\sin 103.34} = 3.29\,kN$$ ②

$$\rightarrow T_{BC} = 5\,\frac{\sin A}{\sin 103.34} = 5\,\frac{\sin 36.87}{\sin 103.34} = 3.08\,kN$$ ③

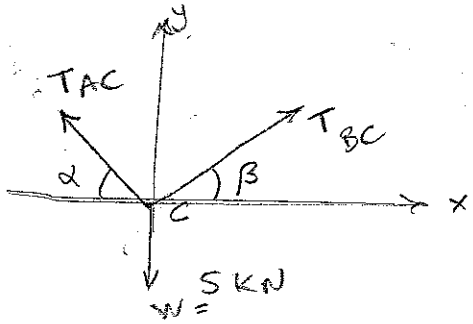
Problem 2:

Two cables are tied together at C and are loaded as shown. Determine the tension (a) in cable AC, (b) in cable BC. (30 marks)



(alternative method is using trigonometry)

FBD:



④

① ① ①

$\sum F_x = 0 \Rightarrow -T_{AC}\cos\alpha + T_{BC}\cos\beta = 0$ ③

① $\sum F_y = 0 \rightarrow T_{AC}\sin\alpha + T_{BC}\sin\beta - W = 0$ ③

$\cos\alpha = \frac{1.5}{AC}$ ①, $AC = \sqrt{2^2+1.5^2} = 2.5$ ① $\rightarrow \cos\alpha = \frac{1.5}{2.5} = 0.6 \rightarrow \sin\alpha = 0.8$ ① ①

$\cos\beta = \frac{2.5}{BC}$ ① $BC = \sqrt{3^2+2.5^2} = 3.9$ ① $\rightarrow \cos\beta = \frac{2.5}{3.9} = 0.64 \rightarrow \sin\beta = 0.768$ ① ①

$\rightarrow \quad 0.6\,T_{AC} = 0.64\,T_{BC}$ ② $\rightarrow T_{AC} = \frac{0.64}{0.6}T_{BC}$ ②

$\rightarrow \quad 0.8\,T_{AC} + 0.768\,T_{BC} = 5$ ② $\Rightarrow$

$T_{BC} = 3.08\ kN$ ②

$T_{AC} = 3.29\ kN$ ②

② $R_2^2 = 226.5^2 + 150^2 - 2(150)(226.5)\cos(115.74)$

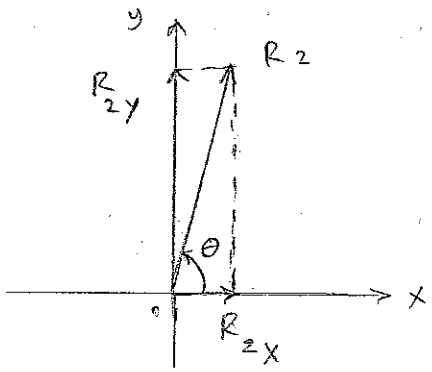
$\rightarrow \underline{R_2 = 321.4 \text{ N}}$ ②

$\frac{R_2}{\sin 115.74} = \frac{150}{\sin\gamma}$ ①

$\rightarrow \sin\gamma = (\sin 115.74)\left(\frac{150}{321.4}\right) = 0.42$ ② $\rightarrow \gamma = 24.86^\circ$ ①

$\rightarrow \theta = 180 - (50 + \beta + \gamma) = 180 - (50 + 24.86 + 15.74) = 89.4^\circ$ ②

(b)



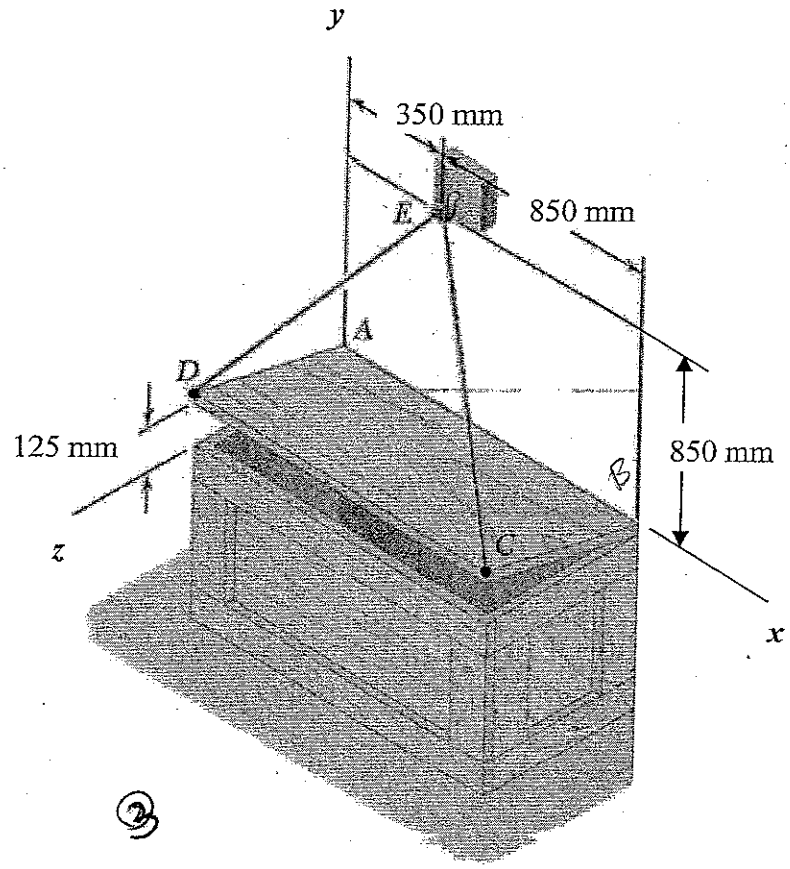
②

$\rightarrow R_{2x} = R_2 \cos\theta = 321.4\cos(89.4) = 3.37 \text{ N}$ ③

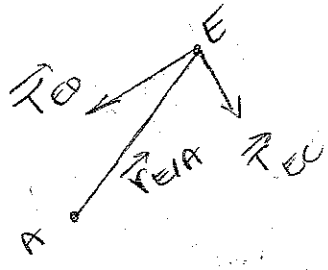
$R_{2y} = R_2 \sin\theta = 321.4 \sin(89.4) = 321.38 \text{ N}$ ③

Problem 3

The 700 mm x 1200 mm lid ABCD of a storage unit is hinged along side AB and is held open by looping chord DEC over a frictionless hook at E. If the tension in the chord is 60 N, determine (a) the moment about A, and (b) component of the moment about x axis. (40 marks)



(3)



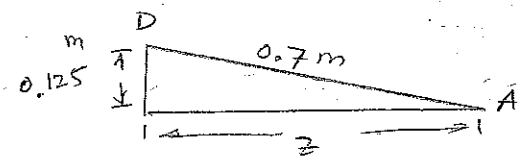
FBD

A(0, 0, 0) (1)

D(0, 0.125, 0.689) (1)

C(1.2, 0.125, 0.689) (1)

E(0.35, 0.85, 0) (1)



(1)

$z = \sqrt{0.7^2 - 0.125^2} = 0.689$ m (1) (1)

$$\vec{M} = \vec{M}_1 + \vec{M}_2 = \vec{r}_{E/A} \times \vec{T}_{ED} + \vec{r}_{E/A} \times \vec{T}_{EC} = \vec{r}_{E/A} \times (\vec{T}_{ED} + \vec{T}_{EC})$$ ①

$$\vec{r}_{E/A} = \vec{AE} = 0.35\vec{i} + 0.85\vec{j}$$ ②

$$\vec{T}_{ED} = T_{ED} \frac{\vec{ED}}{|\vec{ED}|}$$ ①

$$|\vec{ED}| = \sqrt{0.35^2 + 0.725^2 + 0.689^2} = 1.06 \text{ m}$$ ①

$$\vec{ED} = -0.35\vec{i} + 0.725\vec{j} + 0.689\vec{k}$$ ②

$$\rightarrow \vec{T}_{ED} = 60\left(-\frac{0.35}{1.06}\vec{i} - \frac{0.725}{1.06}\vec{j} + \frac{0.689}{1.06}\vec{k}\right) = -19.81\vec{i} - 41.04\vec{j} + 39.0\vec{k}$$ ② ①

$$\vec{T}_{EC} = T_{EC} \frac{\vec{EC}}{|\vec{EC}|}$$ ①

$$|\vec{EC}| = \sqrt{0.85^2 + 0.725^2 + 0.689^2} = 1.31 \text{ m}$$ ①

$$\vec{EC} = 0.85\vec{i} - 0.725\vec{j} + 0.689\vec{k}$$ ②

$$\rightarrow \vec{T}_{EC} = 60\left(\frac{0.85}{1.31}\vec{i} - \frac{0.725}{1.31}\vec{j} + \frac{0.689}{1.31}\vec{k}\right) = 38.93\vec{i} - 33.21\vec{j} + 31.37\vec{k}$$ ② ①

$$\vec{T}_{ED} + \vec{T}_{EC} = (-19.81 + 38.93)\vec{i} - (41.04 + 33.21)\vec{j} + (39.0 + 31.37)\vec{k}$$ ②

$$= 19.12\vec{i} - 74.25\vec{j} + 70.37\vec{k}$$ ①

$$\vec{M} = \vec{r}_{E/A} \times (\vec{T}_{ED} + \vec{T}_{EC}) = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0.35 & 0.85 & 0 \\ 19.12 & -74.25 & 70.37 \end{vmatrix} = 59.81\vec{i} - 24.63\vec{j} + 42.24\vec{k}$$

② ② ②

$$\rightarrow M_x = 59.81 \text{ N.m}$$ ②