# American University of Beirut
# Department of Civil and Environmental Engineering

**Spring 2002-2003** **Instructor: Professor Fouad Kasti**

| CIVE 210 | Statics | Exam # 1 | Sat Mar 22, 03 | 1/1 |
|---|---|---|---|---|

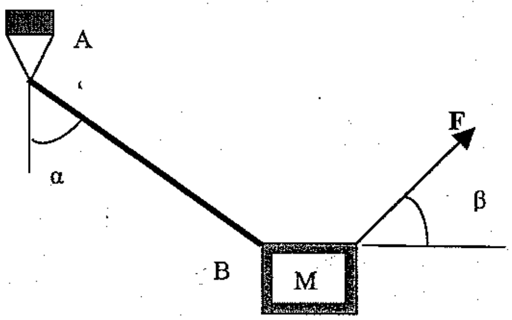
## Problem #1: (50%)

A 50 Kg mass M is attached at B to a single weightless cable AB, length = 10cm and hinged at A. The cable is in equilibrium at the position shown (angle $\alpha$ with the vertical) when subjected to a force F making an angle $\beta$ with the horizontal.

a- What is the minimum possible force in cable AB? Determine $\alpha$, $\beta$ and the magnitude of the force F.

b- If $\alpha = 30°$ and $\beta = 0$, determine the magnitude of the force F and cable tension.

c- If $\alpha = 30°$, determine the minimum magnitude of force F. What is the corresponding cable AB tension and angle $\beta$.



## Problem #2: (50%)

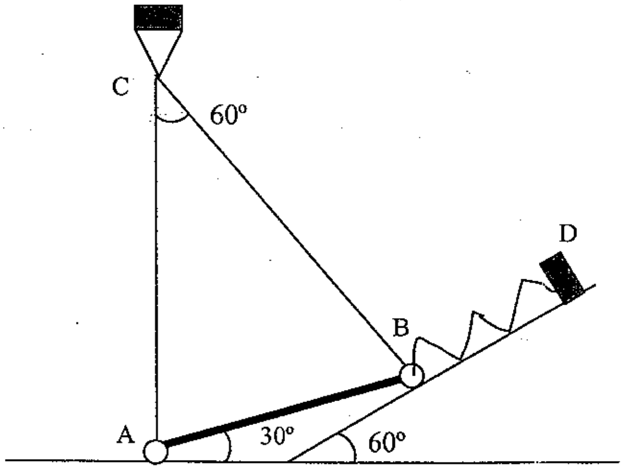
A 20cm, 10 Kg homogeneous uniform bar is roller supported at A and B. The inclined plane makes 60° with the horizontal while bar AB makes a 30° angle with the horizontal. Spring BD has stiffness K=10 Kg/cm. Bar AB is supported at A and B by cables AC and BC hinged at C. Bar AB is in equilibrium and barely touching the horizontal and inclined planes. Bar AC is vertical. Bar BC makes a 60° angle with AC. Assume frictionless surfaces.

a- Find tension in cable AC.

b- Find force in spring BD. Specify tension or compression.

c- Compute deformation in spring BD.
Specify shortening or elongation.

d- Find tension in cable BC.



# American University of Beirut
# Department of Civil and Environmental Engineering

**Fall 2000-2001** **Instructor: Professor Fouad Kasti**

Problem #1: (30%) CONCEPT ERROR = - 10, CALCULATION ERROR = - 5, NOTHING DONE $\frac{0}{15}$

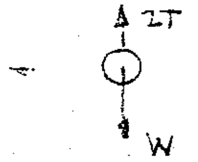
A cable is wound around pulleys at A, B, and C. Another cable winds around pulleys C and D as shown. The pulleys are frictionless and dimensionless. Cables tensile capacity (maximum allowed tension force) is 100N. Points A and B are hinged:

1- For d = 20cm, compute the maximum weight W that the system can carry. (15%)

2- Determine the optimum value of d to maximize the carried weight W (that is what is the value of d that will allow the cable system to carry the highest possible weight W ?). For this optimum d, compute the weight W. (15%)

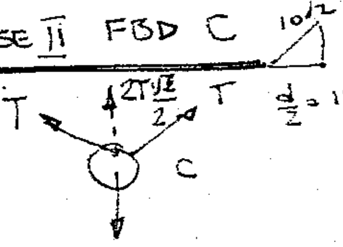
PART I

① CASE I : FBD D



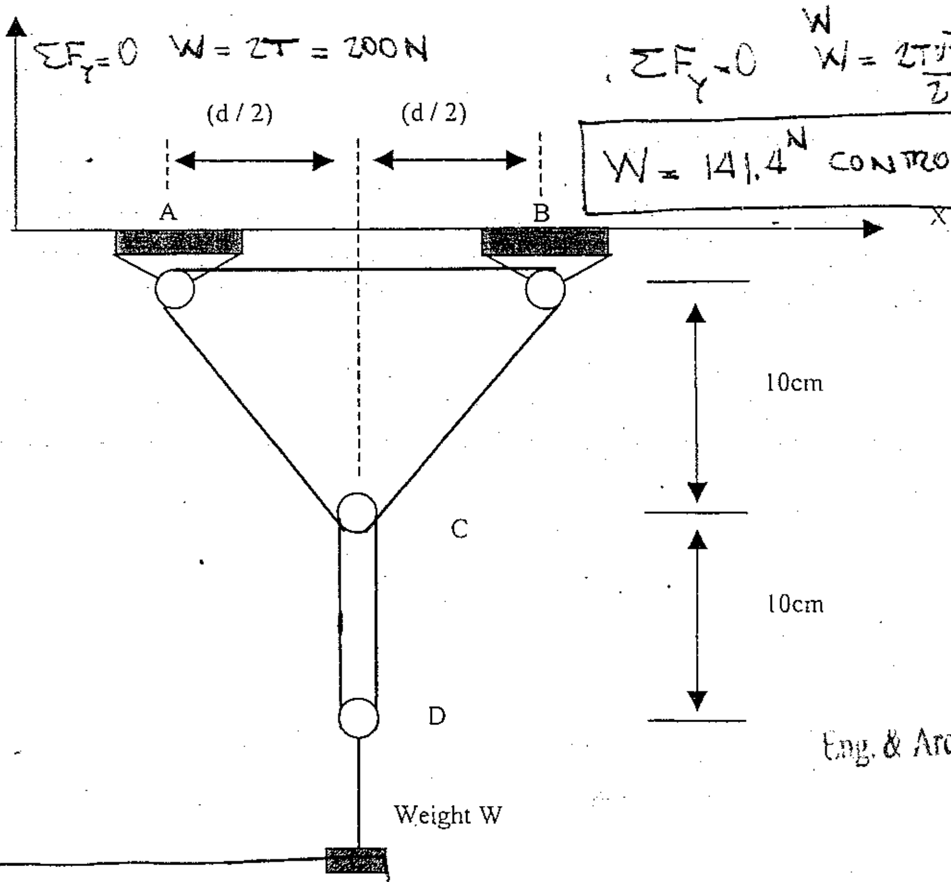
$\Sigma F_Y = 0 \quad W = 2T = 200 \text{ N}$

② CASE II FBD C



$\Sigma F_Y = 0 \quad W = \frac{2T\sqrt{2}}{2} = 100\sqrt{2} = 141.4$

$\boxed{W = 141.4^{N} \text{ CONTROLS}}$



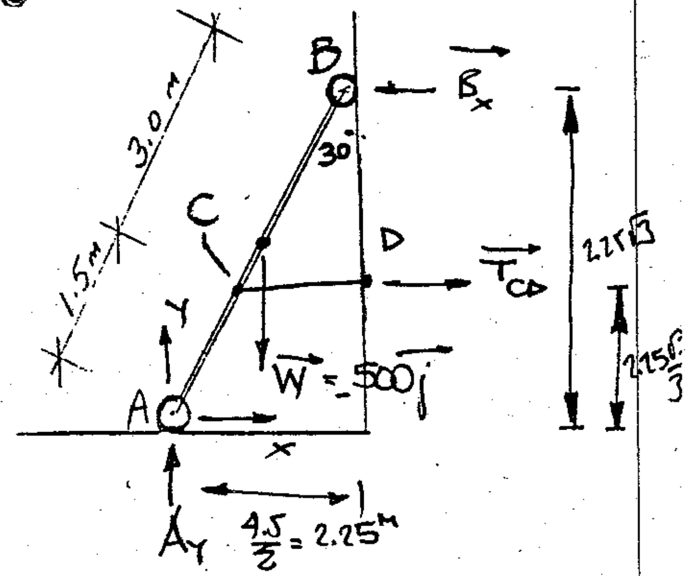
PART II

$\boxed{d = 0 \quad W = 200 \text{N}}$

## American University of Beirut
## Department of Civil and Environmental Engineering
**Fall 2000-2001** **Instructor: Professor Fouad Kasti**

Problem #1: (30%)

The uniform bar with end rollers weighs 500 N and is held in equilibrium in the position shown by the horizontal cable CD. Determine the reactions at A&B & the tension in the cable.



$\Sigma F_x = 0 \qquad B_x = T_{CD}$

$\Sigma F_Y = 0 \qquad A_Y = W = 500^N$

$$\Sigma M_A = 0 \qquad \overset{\curvearrowright}{W * \frac{2.25}{2}} + \overset{\curvearrowright}{T_{CD}\, 2.25\frac{\sqrt{3}}{3}} - \overset{\curvearrowleft}{B_x\, 2.25\sqrt{3}} = 0$$

$$500 \times \frac{\cancel{2.25}}{2} - \left(\frac{2}{3} T_{CD}\right)\cancel{2.25}\sqrt{3} = 0 \qquad T_{CD} = \frac{250^N}{\frac{2}{3}\sqrt{3}} = \boxed{216.5^N = T_{CD} \text{ TENSION}}$$

$$\boxed{B_x = T_{CD} = 216.5^N \leftarrow}$$

$$\boxed{A_Y = 500^N \uparrow}$$

# American University of Beirut
## Department of Civil and Environmental Engineering
Fall 1999-2000 Instructor: Professor Fouad Kasti

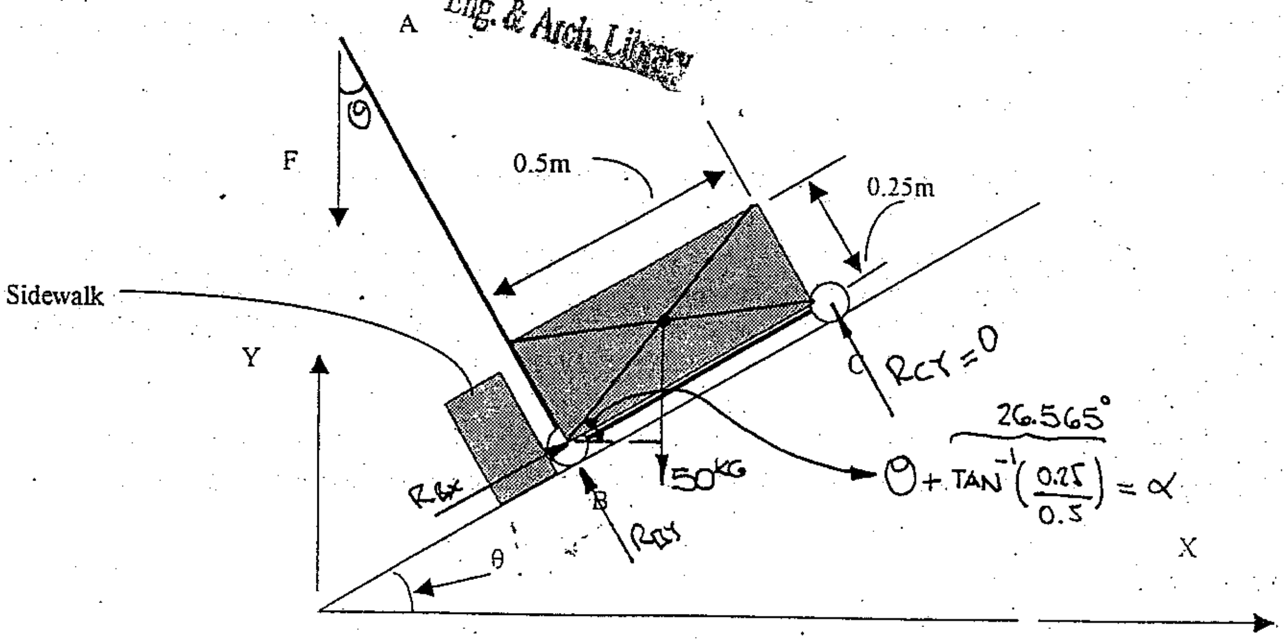
Problem #1: (30%)

The rigid loading/unloading equipment (ABC) shown is used to pickup objects from an inclined frictionless loading dock making an angle θ with the horizontal surface. The equipment rolls on wheels at B and C. The object is rectangular in shape, 0.50 m long and 0.25 m high and weighs 50 kg. Member AB is 2.0m long perpendicular to member BC. Member BC is 0.5m long.

15% 1- Compute the vertical force F (in kg) acting at A needed to pickup the object (object loaded) and roll the equipment on wheel B only. Assume angle θ is 30°.

15% 2- For F = 0, compute maximum angle θ (in degrees) before the equipment overturns with the object picked up (object loaded).

DIAGONAL $= \sqrt{0.25^2 + 0.5^2} = 0.559^M$



FBD

EQUILIBRIUM ABOUT POINT B: $\Sigma M_B = 0$

$$F(2\sin\theta) = 50 * \frac{0.559}{2} \cos\alpha$$

(1-) $\theta = 30^\circ$, $\alpha = 56.565^\circ$: $F = \left[50 * \frac{0.559}{2} \cos\alpha\right] / (2\sin\theta) \Rightarrow \underline{F = 7.70^{KG}}$

$F = 50 * 0.154 / 1.0$

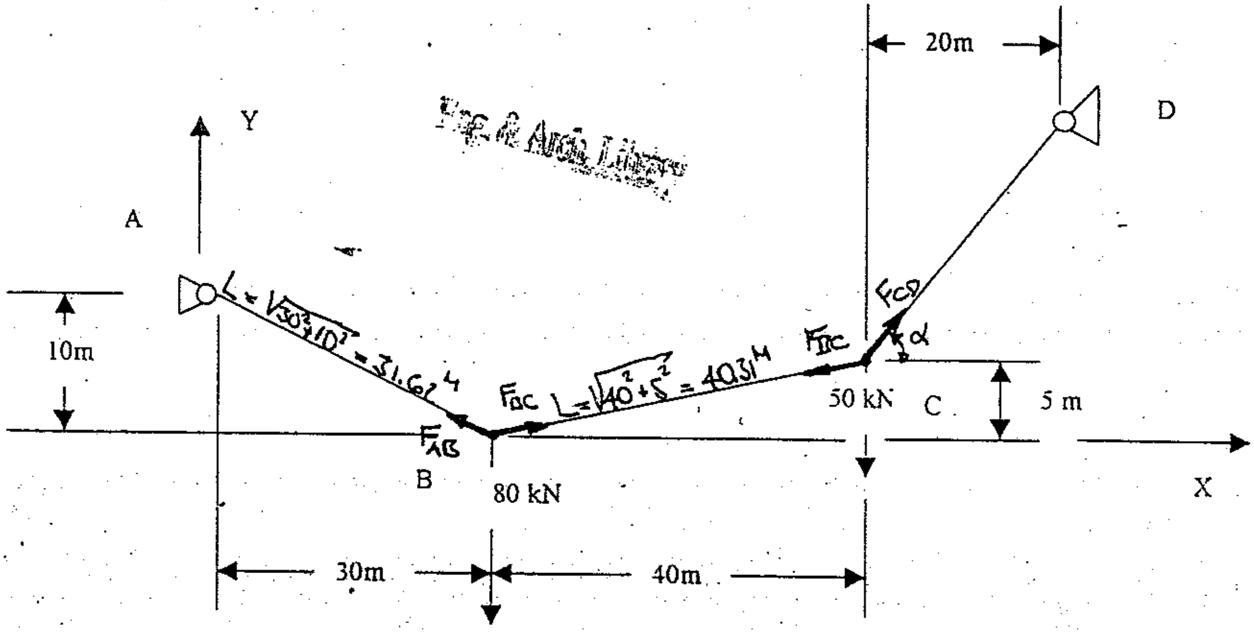
(2-) $F = 0$: $\longrightarrow \cos\alpha = 0$, $\alpha = 90^\circ$, $\theta = 90 - 26.565 \Rightarrow \underline{\theta = 63.44^\circ}$

# American University of Beirut
# Department of Civil and Environmental Engineering

Fall 1999-2000 Instructor: Professor Fouad Kasti

**Problem #2: (30%)**

The cable system shown is used to support a pedestrian bridge. The pedestrian bridge applies 80KN and 50 KN concentrated loads at points B and C respectively. Determine the tension forces in cables AB, BC and CD in KN and the difference in elevation between points A and D in m.



(15%) **FBD @ B:**

$$\Sigma F_x = 0, \quad \frac{40}{40.31} F_{BC} = \frac{30}{31.62} F_{AB} \longrightarrow F_{AB} = 1.046 F_{BC}$$

$$\Sigma F_y = 0, \quad \frac{5}{40.31} F_{BC} + \frac{10}{31.62} F_{AB} = 80 \longrightarrow \underline{F_{BC} = 175.9^{kN}} \quad \underline{F_{AB} = 184.0^{kN}}$$

(15%) **FBD @ C:**

$$\left.\begin{aligned} \Sigma F_x = 0, \quad & \frac{40}{40.31} F_{BC} = F_{CD} \cos\alpha \\ \Sigma F_y = 0, \quad & \frac{5}{40.31} F_{BC} = F_{CD} \sin\alpha - 50 \end{aligned}\right\} \quad \tan\alpha = \frac{\frac{5}{40.31} F_{BC} + 50}{\frac{40}{40.31} F_{BC}} = 0.4115$$

$$\underline{\alpha = 22.37^\circ} \quad \& \quad \underline{F_{CD} = 188.7^{kN}}$$

$$(CD)_Y = 20 \tan(\alpha) = 8.23^M$$

$$(AD)_Y = 8.23^M + 5^M - 10^M = \underline{3.23^M = AD_Y}$$

# American University of Beirut
## Department of Civil and Environmental Engineering

[redacted] 2001-2002
Instructor: Professor Fouad Kasti

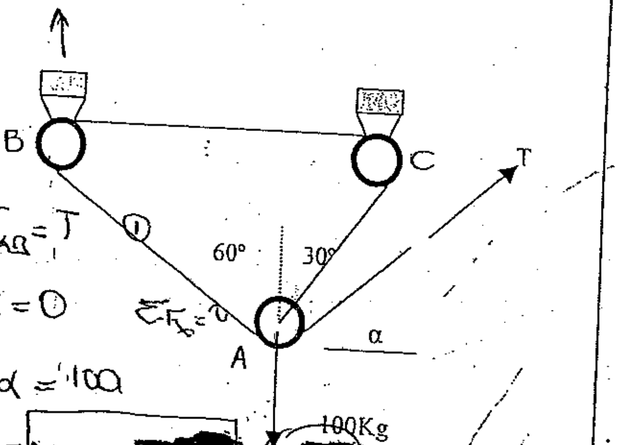
Problem #1: (30%)

A single cable is pulled from one end with a force T. The cable wraps around pulleys A, B and C as shown then ties back to pulley A. Segment AB of the cable makes 60° with the vertical direction while segment AC makes 30° with the vertical. Pulley A carries a 100 Kg mass. Neglect pulley dimensions.

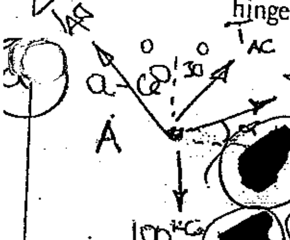
a- Find the force T and the angle α (with the horizontal) required to carry the 100 Kg mass.

b- Determine the cable force in segment BC.

c- Compute the reaction at Pulley B assuming hinge supports at B and C.



a-



$T_C = T_{AC} = T_{AB}$ SAME CABLE $T_{AC} = T_{AB} = T$

[redacted] ② $T_{AC}\cos 60 - T_{AB}\cos 30 + T\cos\alpha = 0$ $\Sigma F_x = 0$

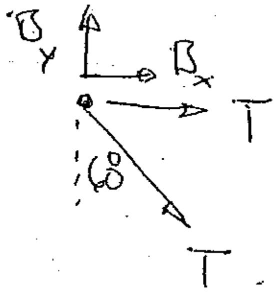
[redacted] ③ $T_{AC}\cos 30 + T_{AB}\cos 60 + T\sin\alpha = 100$

[redacted]

[redacted]

b- $T_{BC} = \boxed{T = \text{[redacted]}}$ [redacted]

c-



$\Sigma F_y = 0$ $B_y = T\cos 60 =$ [redacted]

$\Sigma F_x = 0$ $B_x + T + T\sin 60 = -81.25$

[redacted]

# American University of Beirut
## Department of Civil and Environmental Engineering
[redacted] 2001-2002 Instructor: Professor Fouad Kasti

Problem #2: (35%)

A plane is subjected to two forces $F_a$ and $F_b$ as shown in the figure below (hinge at D, roller at C).

a- If $F_a = 450N$, $\alpha = 30°$ and $F_b = 0$: determine the moment of $F_a$ about point D.

b- If $F_a = 0$: what is the smallest force $F_b$ and angle β (with the horizontal) that will produce the same moment computed in a- about point D.

c- If $F_b = 0$: what is $F_a$ and α (with the vertical) so that the reaction at C is zero.

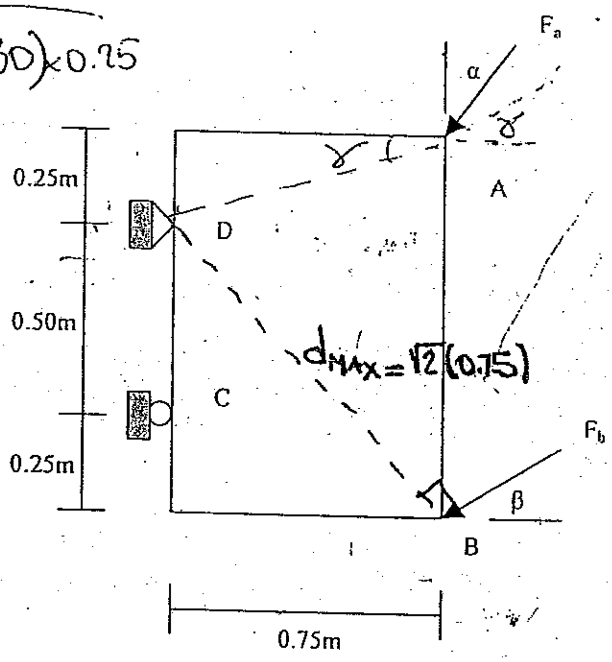
(a-) $M_D = 450\cos(30)\times 0.75 - 450\sin(30)\times 0.25$

[redacted] [redacted]

(b-) $M_D = 236.03 = F_b \times 0.75\sqrt{2}$

[redacted] [redacted]

$\boxed{\beta = 45.0}$ [redacted]



(C-) $F_a$ = ANY VALUE [redacted]

$\alpha = 90 - \gamma =$ [redacted] = [redacted]

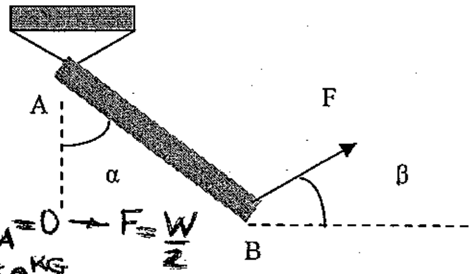
7 PT

# American University of Beirut
# Department of Civil and Environmental Engineering

**Fall 2004-2005** **Instructor: Professor Fouad Kasti**

**Problem #1: (50%)**

A uniform, homogeneous bar AB is 10cm long and weighs 100 kg. AB is hinge supported at A, makes an angle α with the vertical and is subjected to a force F at end B making an angle β with the horizontal.



1- What is the minimum force F and the corresponding angles α and β (10%) ? $\boxed{F=0 \quad \alpha=0 \quad \beta=\text{ANY}}$

2- Assuming α ≠ 0, β ≠ 0 and F ≠ 0, what is the minimum horizontal reaction at A and the corresponding force F and angles α and β (20%) ? $\boxed{H_A=0,\ \beta=90^\circ,\ \alpha=\text{ANY}}$ $\Sigma M_A=0 \rightarrow F=\frac{W}{2}$

$F=50^{KG}$

3- Assuming α ≠ 0, β ≠ 0 and F ≠ 0, what is the value of the angle β for the force F to be minimum ? For α = 45, what is β and the corresponding minimum force F ? (20%)

$\vec{F} \perp AB \rightarrow \boxed{\alpha=\beta} \qquad \alpha=45 \rightarrow \boxed{\beta=45}$

$\Sigma M_A=0 \rightarrow (AB)F = W\left(\frac{AB}{2}\right)\sin\alpha \rightarrow F=\frac{W}{2}\sin\alpha=\frac{50\sqrt{2}}{4}=\boxed{35.4^{K}=F}$

**Problem #2: (50%)**

Springs I and II have 100N/cm spring stiffness each and are parallel to edges AB and BC respectively. Spring I is attached to a mass $M_I$ while spring II is attached to mass $M_{II}$. The contact at both masses $M_I$ and $M_{II}$ is frictionless with edges AB and BC respectively. Springs I and II are attached to a cable that winds around a pulley at B. Edges AB and BC make angle α and β with the horizontal respectively, γ is the angle between edges AB and BC, $M_I$ = 50 kg:

1- Assuming angle α = 30° and angle γ = 90°: (25%)

- a- Find the elongations in springs I and II respectively
- b- Find the corresponding mass $M_{II}$ carried at the end of spring II

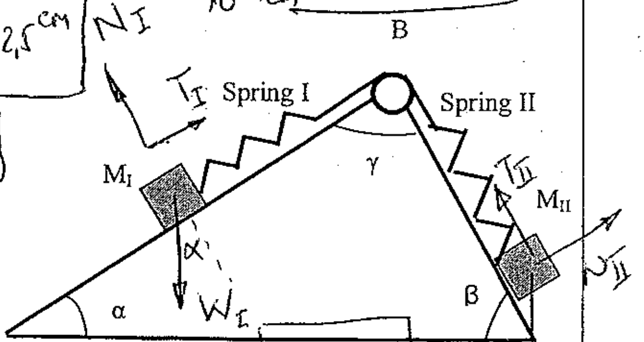
2- Assuming $M_{II}$ = 100 kg: (25%)

- a- Find the maximum possible cable tension force for the cable joining springs I and II
- b- Find angles α, β and γ
- c- Find elongations in springs I and II

① $\Sigma F_{AB}=0 \rightarrow \omega_I\sin\alpha=T_I=50\sin30=\boxed{25^{KG}=T_I}$ $\quad \Delta_I=\frac{25^{KG}}{10^{KG/cm}}=\boxed{2.5^{CM}=\Delta_I}$

$T_{II}=T_I \qquad \omega_{II}\sin\beta=\boxed{T_{II}=25^{KG} \quad \Delta_{II}=2.5^{CM}}$

$\omega_{II}=\frac{25}{\sin60}=\frac{25}{\sqrt{3}/2}=\boxed{28.9^{KG}=W_{II}}$



② $\text{I CONTROLS} \rightarrow T_I^{MAX}=\omega_I\sin\overset{90^\circ}{\alpha}$

$\text{II CONTROLS} \rightarrow T_{II}^{MAX}=\omega_{II}\sin\beta$

$T_{MAX}=\text{MIN}(T_I, T_{II})=\text{MIN}(\omega_I, \omega_{II})$

$T_{II}=50^{KG}=100\sin\beta \quad \beta=\sin^{-1}\frac{1}{2} \quad 90^\circ \quad \boxed{T_{MAX}=50^{KG}} \quad \boxed{\Delta_I=\Delta_{II}=\frac{50}{10}=5^{CM}} \quad \boxed{\begin{array}{l}\alpha=90^\circ\\ \beta=30^\circ\\ \gamma=60^\circ\end{array}}$

# American University of Beirut
# Department of Civil and Environmental Engineering

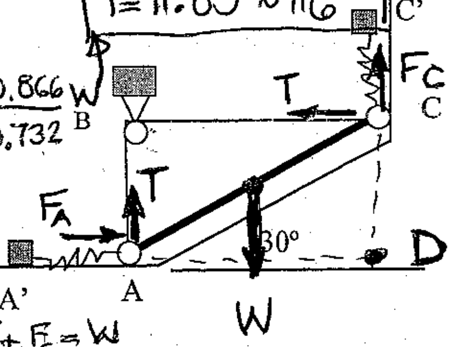
Fall 2005-2006 Instructor: Professor Fouad Kasti

| CIVE 210 | Statics | Exam # 1 | Sat Nov 12, 05 | 1/1 |
|---|---|---|---|---|
| | | 1 ½ Hour Exam, Closed Books | | |

Problem #1: (45%)

The rigid bar AC shown has 10Kg mass. AC is parallel to the sloping plane which makes an angle of 30° with the horizontal. A single cable connects at A, winds around pulley at B and ties to C. Bar AC is roller supported at ends A and C with dimensionless and frictionless pulleys / surfaces. Assume the length of AC = 20cm and point B hinge supported. Vertical spring CC' and horizontal spring AA' have a spring constant = 100 Kg/cm each. Assume A' and C' fully fixed. Assume cable segment AB vertical and BC horizontal. Pulleys at A and C are barely touching the horizontal and vertical planes.

$\boxed{T = 11.83^{KG} \sim 116^{N}}$



a- Draw the Free Body Diagram and indicate clearly all necessary information (6%)

$T\left(\frac{\sqrt{3}}{2}\right)-\left(\frac{1}{2}\right) = W\frac{\sqrt{3}}{4}$ $T = \frac{0.866W}{0.732}$

b- Determine the tension force in cable ABC (13%)

$\Sigma M_D = 0\ T\left(AC\frac{\sqrt{3}}{2}\right) - \frac{W}{2}\left(AC\frac{\sqrt{3}}{2}\right) - T\left(\frac{AC}{2}\right) = 0$

c- Determine the forces in springs AA' & CC'. Indicate tension or compression. (13%)

$\Sigma F_x = 0$ $\boxed{F_A = T \approx 11.83^{KG}(C)}$

$\Sigma F_y = 0\ T + F_C = W$

$F_C = W - T = W - 1.183W$

$F_C = -0.183W \boxed{= 1.83^{KG}(C) = F_C}$

d- Determine ~~the change in length in springs~~ AA' & CC'. Indicate elongation or shortening. (13%)

$\Delta_A = \frac{F_A}{K} = 0.12^{CM}$ SHORTENING

$\Delta_C = \frac{F_C}{K} = 0.018^{CM}$ SHORTENING

Problem #2: (30%)

The rigid weightless & dimensionless bar ABC is fully fixed at A and connects to a dimensionless & frictionless pulley at C. A single cable connects at D (hinged supported) and winds around C with a force F applied at its free end at an angle α with the horizontal. Assume force F = 10N, length of AB = 20cm, length of BC = 5cm

$AC = \sqrt{20^2+5^2} = 20.62^{CM}$

$\Sigma M_A = 0, M_A + F(5) - F(20) = 0$ $\boxed{M_A = 150\ N\text{-}CM}$

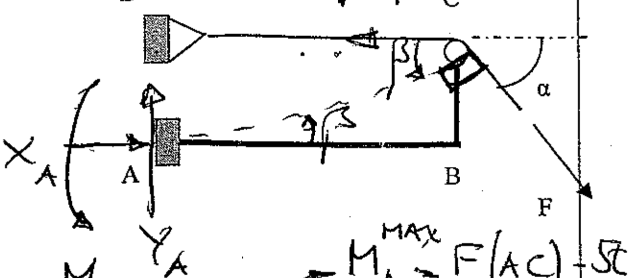
$T = F$

a- Draw the Free Body Diagram and indicate clearly all necessary ~~information (6%)~~

$\Sigma F_y = 0$ $\boxed{Y_A = F = 10N}$

b- Determine ~~the reactions at A when α = 90°~~ (12%)

$\Sigma F_x = 0\ X_A = F = \boxed{10N = X_A}$



c- Determine the angle α and the reactions at A when the moment reaction at A is maximum (12%)

$M_A = F(d_F) - T*5$ $M_A^{MAX} \Rightarrow d_F = MAX$

$\Rightarrow d_F = AC \perp F$

$M_A^{MAX} = F(AC) - 5T$

$\boxed{M_A^{MAX} = 156.2^{N\text{-}cm}}$

$\beta = \tan^{-1}\left(\frac{5}{20}\right) \simeq 14.04^{\circ}$ $\alpha = 90 - \beta = \boxed{75.96 = \alpha}$

$\Sigma F_y = 0$ $Y_A = 10\sin 75.96 = \boxed{9.7^{KG} = Y_A}$ $\Sigma F_x = 0$ $X_A = 10 - 10\cos 75.96 = \boxed{7.6^{KG} = X_A}$

# American University of Beirut
# Department of Civil and Environmental Engineering

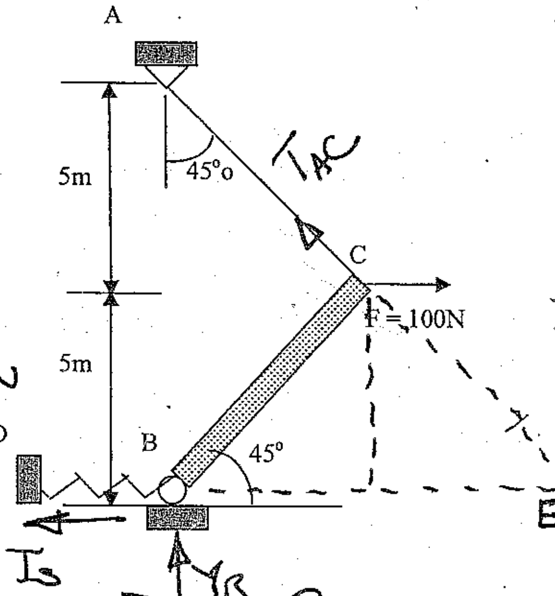
**Spring 2005-2006** **Instructor: Professor Fouad Kasti**

| CIVE 210 | Statics | Exam # 1 | Sat Mar 25, 06 | 1/1 |
|---|---|---|---|---|

**1 1/2 Hour Exam, Closed Books**

Problem I (40%):

The rigid weightless bar BC is roller supported at B, attached to a weightless cable AC at C, and is connected to spring BD at B as shown. A horizontal F = 100N force is applied at C with a spring constant K of 100N/cm. Cable AC is hinge supported at A. Spring BD is fully fixed at D. Assume frictionless roller at B. The system is in equilibrium.



1- Draw a free body diagram (5%)

2- Find the spring force and corresponding deformation. Indicate tension/compression or elongation/shortening (15%)

$\Sigma M_A = 0$ $T_S = 50^N$ $\Delta = 0.5^{cm}$ ← ELONGATION

3- Find tension force in cable AC (10%)

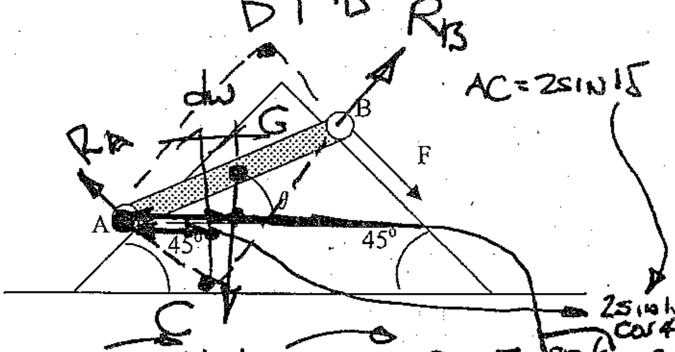
$\Sigma M_B = 0$ $100 * 5/5\sqrt{2} = T_{AC} = 50\sqrt{2}$

4- Find the reaction at roller B (magnitude and direction) (10%)

$\Sigma M_E = 0$ $100 * \frac{5}{10} = 50^N \downarrow$

Problem II (35%):

The rigid bar AB is roller supported at A & B along two inclined planes making 45° as shown. A force F is applied at B along the slope. Assume frictionless rollers at A & B, 2m length of bar AB and 50N weight of bar AB. The system is in equilibrium.



1- Draw a free body diagram (5%)

2- For an angle θ = 30, find the following: (15%)
   a- The force F (magnitude and direction)
   b- The reaction at A (magnitude and direction)
   c- The reaction at B (magnitude and direction)

$\Sigma M_C = 0$ $F(BC) W + W d\omega = 0$ $F = \frac{50}{BG}\left(\frac{2\cos 30}{2}\right)$

$F = \frac{50}{BC} * 0.5 = \boxed{12.5^N = F}$

3- Find the minimum possible force F (magnitude and direction) and the corresponding angle θ as well as the magnitude and directions of the reactions at A and B. (15%)

$\Sigma M_B = 0$

$R_A(BC) - W(BG)_H = 0$

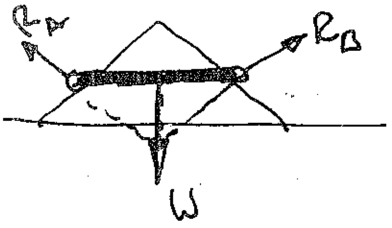
$R_A = \frac{50 * (1\cos 30)}{2\cos 15} = \boxed{22.42 = R_A}$

$F_{MIN} = 0$

$\theta = 0$

$R_A = R_B = W\frac{\sqrt{2}}{2} = 50\frac{\sqrt{2}}{2}$

$= 25\sqrt{2}$



$\Sigma M_A = 0$

$\Sigma F_{R_B} = 0$ $R_B - W\cos 45 = 0$

$R_B = 50\frac{\sqrt{2}}{2} = \boxed{35.35^N = R_B}$

# American University of Beirut
# Department of Civil and Environmental Engineering

**SPR 2004-2005** **Instructor: Professor Fouad Kasti**

| CIVE 210 | Statics | Exam # 1 | Sat Mar 19, 05 | 1/1 |
|---|---|---|---|---|
| | | 1 ½ Hour Exam, Closed Books | | |

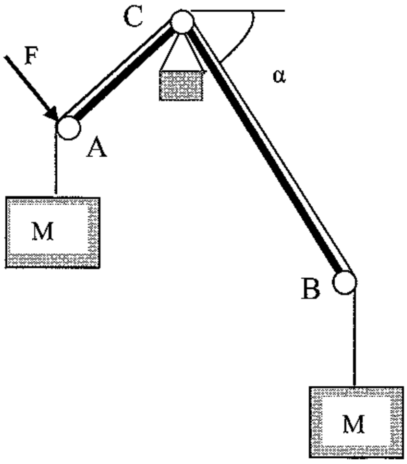
Problem #1: (50%)

A 100 Kg mass M is attached to a weightless cable (referred to cable ACB below) at A and B that wounds around pulley at A, then pulley C and finally pulley B. Bar ABC is a single bar with a hinge support at C. The length of segment AC = 10cm, length of segment BC = 20cm, angle between segment AC and segment BC = 90°. Bar ABC is weightless, hinged supported at C and is allowed to rotate about point C. The position of bar ABC is given by the angle α that segment /cable BC makes with the horizontal. Bar ABC is subjected to a force F perpendicular to segment AC and applied at A as shown. Neglecting pulley geometries and assuming frictionless pulleys and surfaces:

a- With F = 0, determine the angle α required for equilibrium. (15%)

b- With segment AB horizontal, determine the required force F and the corresponding angle α. (15%)

c- What is the maximum force F required for equilibrium and the corresponding angle α? (20%)



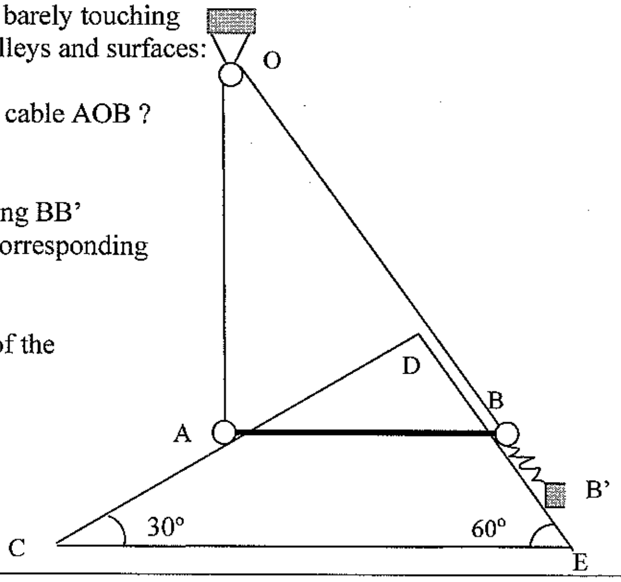
Problem #2: (50%)

A 20cm, 10 Kg homogeneous uniform bar AB is in equilibrium and is restrained at B by a spring of stiffness K = 10 Kg/cm. A single cable (referred to cable AOB) is tied to bar AB at pulley A, wound around pulley O then tied to bar AB at pulley B. Bar AB is horizontal, cable segment AO is vertical, cable segment BO is parallel to edge DE, spring BB' is fully fixed at B' and is oriented along DE, pulley O is hinged. Neglecting pulley geometries, assuming pulley A barely touching the sloping edge CD and assuming frictionless pulleys and surfaces:

a- What is the magnitude of tension force in cable AOB ? (15%)

b- What is the magnitude of the force in spring BB' (specify tensile or compressive) and the corresponding elongation ? (15%)

c- Determine the magnitude and directions of the reactions at O and B (20%)



# American University of Beirut
# Department of Civil and Environmental Engineering

**Summer 2005-2006** **Instructor: Professor Fouad Kasti**

| CIVE 210 | Statics | Exam # 1 | Mon Sep 11, 06 | 1/1 |
|---|---|---|---|---|
| | | 1 ½ Hour Exam, Closed Books | | |

## Problem #1: (40%)

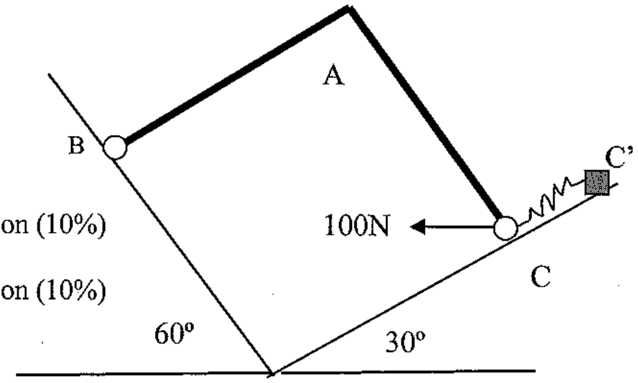
Bars AB and AC are roller supported at B and C and rigidly interconnected at A. Spring CC' is parallel to the sloping plane which makes an angle of 30° with the horizontal. A 100N horizontal concentrated force is applied at C. Spring stiffness K = 100N/cm. Length of AB = 8cm and length of AC = 12cm. Assume uniform and weightless rigid bars AB and AC. Assume dimensionless and frictionless rollers / surfaces at B and C. Assume C' fully fixed.

a- Draw Free Body Diagram. Indicate clearly all necessary information (5%)

b- Determine the tension force and deformation in spring CC' (15%)

c- Determine the reaction at C, magnitude and direction (10%)

d- Determine the reaction at B, magnitude and direction (10%)



## Problem #2: (60%)

The uniform and rigid bar AB is 20cm long and 100N in weight. Point A is hinge supported while point B is connected to a single weightless cable winding around a hinge supported, dimensionless and frictionless pulley at C and is then connected to a mass M at D. Assume mass M is rolling on a frictionless surface at D. Assume cable segment BC is vertical and cable segment CD is parallel to the plane at angle $\beta$ with the horizontal.

a- Draw Free Body Diagrams of AB and M. Indicate clearly all necessary information (10%)

b- Determine the reaction at A, cable force in segment BC, cable force in segment CD, mass M and the reaction at D when $\alpha = 60^\circ$ and $\beta = 30^\circ$ (30%)

c- Determine the angles $\alpha$ and t $\beta$, the reactions at A and cable forces in segments BC and CD and the mass M, when the required mass M for equilibrium is Minimum (20%)