TEST 1
Fall 2015
(15 October, 2015)
CIE200 – STATICS
CLOSED BOOK, 75 MINUTES

Name: F. El Meski, PhD, PE **ID#:** Fall 2015 **Section:** 12 & 13

NOTES

- 3 problems (11 pages).
- All your answers should be provided on the question sheets.
- Two extra sheets is provided at the end.
- Ask for additional sheets if you need more space.
- Some answers may require much less than the space provided.
- ***Do not*** use the back of the sheets for answers.
- ***Every FBD needed for the solution of a problem should be clearly shown.***
- ***Points will be deducted for any missing/ incomplete/incorrect FBD.***
- ***Points will be deducted for answers not supported by proper calculations.***

YOUR COMMENT(S)

_ _

_ _

DO NOT WRITE IN THE SPACE BELOW

MY COMMENT(S)

_ _

_ _

YOUR GRADE

Problem I:	30 /30
Problem II:	35 /35
Problem III	35 /35
TOTAL:	100 /100

Problem I: *(30 points)*

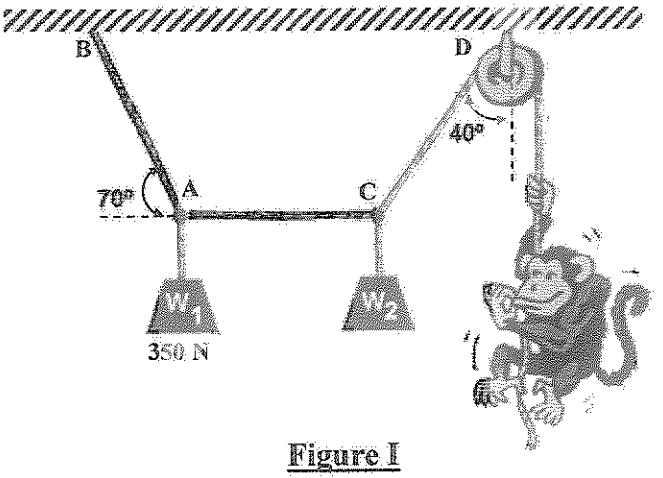


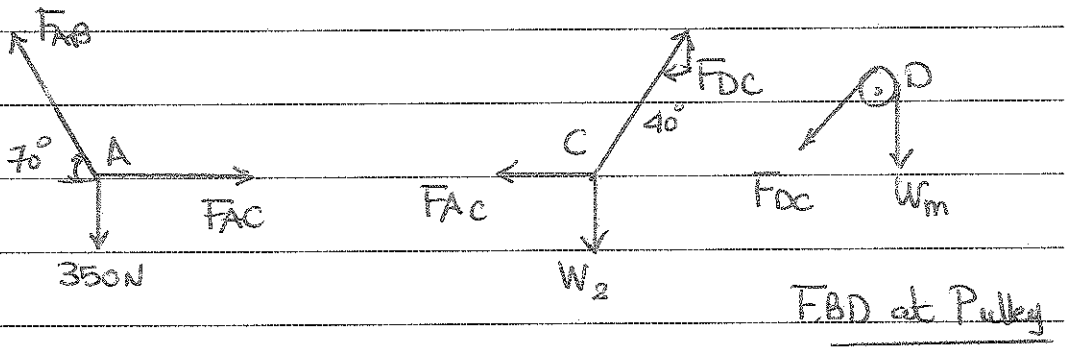
Figure I

The system shown in **Figure I** is in equilibrium.

A monkey is suspended from a **frictionless** pulley at D. Determine the mass of the monkey, and the forces in cables AB, AC, CD, and weight W_2. If W_1=350 N.

Note: FBD must be included

Calculations and/or Diagrams:



Equilibrium at A:

$+\uparrow \sum F_y = 0 \Rightarrow F_{AB}\sin 70 - 350 = 0 \Rightarrow \boxed{F_{AB} = 372.46\ N}$

$+\rightarrow \sum F_x = 0 \Rightarrow -372.46\cos 70 + F_{AC} = 0 \Rightarrow \boxed{F_{AC} = 127.39\ N}$

Calculations and/or Diagrams:

Equilibrium at C:

$\rightarrow \Sigma F_x = 0 \Rightarrow -127.39 + F_{DC} \sin 40 = 0 \Rightarrow \boxed{F_{DC} = 198.2\ N}$

$+\uparrow \Sigma F_y = 0 \Rightarrow 198.2 \cos 40 - W_2 = 0 \Rightarrow \boxed{W_2 = 151.83\ N}$

Equilibrium at D:

Frictionless pulley at D $\Rightarrow F_{DC} = W_m = 198.2\ N$

$\therefore mass = \frac{198.2}{9.81} \Rightarrow \boxed{mass = 20.2\ kg}$

Problem II: *(35 points)*

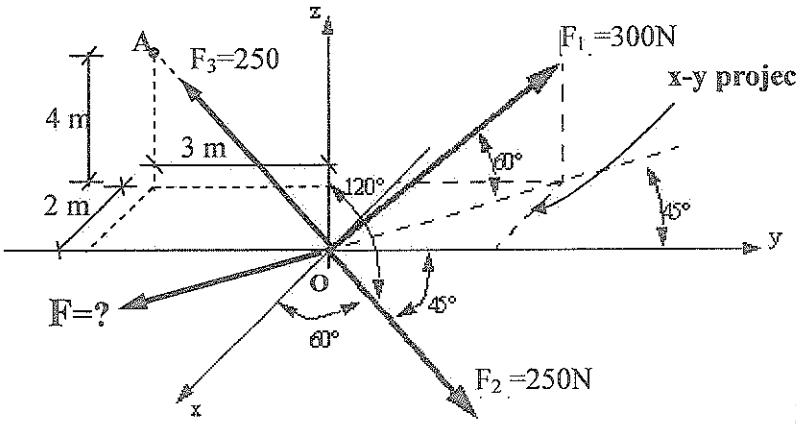
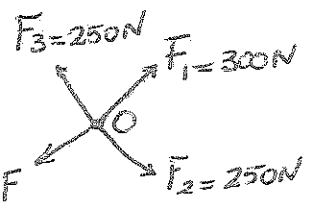


Figure II



F.B.D

The system shown in **Figure II** is subjected to four forces :

1. Determine the force F (magnitude and direction angles) required to keep the particle at O in Equilibrium. Express your result as Cartesian vector.

Calculations and/or Diagrams:

Express each force in Cartesian Vector:

$F_{1x} = -300 \cos 60 \sin 45 = -106.07\ N$

$F_{1y} = 300 \cos 60 \cos 45 = 106.07\ N$

$F_{1z} = 300 \sin 60 = 259.8\ N$

$\therefore \vec{F_1} = \{-106.07\vec{i} + 106.07\vec{j} + 259.8\vec{k}\}^N$

$F_{2x} = 250 \cos 60 = 125\ N$

$F_{2y} = 250 \cos 45 = 176.78\ N$

$F_{2z} = 250 \cos 120 = -125\ N$

$\vec{F_2} = \{125\vec{i} + 176.78\vec{j} - 125\vec{k}\}^N$

Calculations and/or Diagrams (cont'd):

$A(-2,-3,4)$

$$\vec{F}_3 = 250\,\vec{u}_{DA} = 250\left\{\frac{-2\vec{i}-3\vec{j}+4\vec{k}}{\sqrt{(-2)^2+(-3)^2+(4)^2}}\right\} = \{-99.85\vec{i}-139.27\vec{j}+185.7\vec{k}\}\ N$$

$$\vec{F} = \{F_x\vec{i} + F_y\vec{j} + F_z\vec{k}\}$$

Equations of Equilibrium:

$$+\rightarrow \Sigma F_x = 0 \Rightarrow -106.07 + 125 - 99.85 + F_x = 0$$

$$\Rightarrow \boxed{F_x = 73.92\ N}$$

$$+\uparrow \Sigma F_y = 0 \Rightarrow 106.07 + 176.78 - 139.27 + F_y = 0$$

$$\Rightarrow \boxed{F_y = -143.58\ N}$$

$$+\uparrow \Sigma F_z = 0 \Rightarrow 259.8 - 125 + 185.7 + F_z = 0$$

$$\Rightarrow \boxed{F_z = -320.5\ N}$$

- In Cartesian form: $\boxed{\vec{F} = \{73.92\vec{i} - 143.58\vec{j} - 320.5\vec{k}\}\ N}$

Magnitude:

$$F = \sqrt{(73.92)^2 + (-143.58)^2 + (-320.5)^2} =$$

$$\Rightarrow \boxed{F = 358.89\ N}$$

Direction:

$$\cos\alpha = \frac{73.92}{358.89} \Rightarrow \boxed{\alpha = 78.1^\circ}$$

$$\cos\beta = \frac{-143.58}{358.89} \Rightarrow \boxed{\beta = 113.6^\circ}$$

$$\cos\gamma = \frac{-320.5}{358.89} \Rightarrow \boxed{\gamma = 153.26^\circ}$$

Calculations and/or Diagrams (cont'd):

Problem III: *(35 points)*

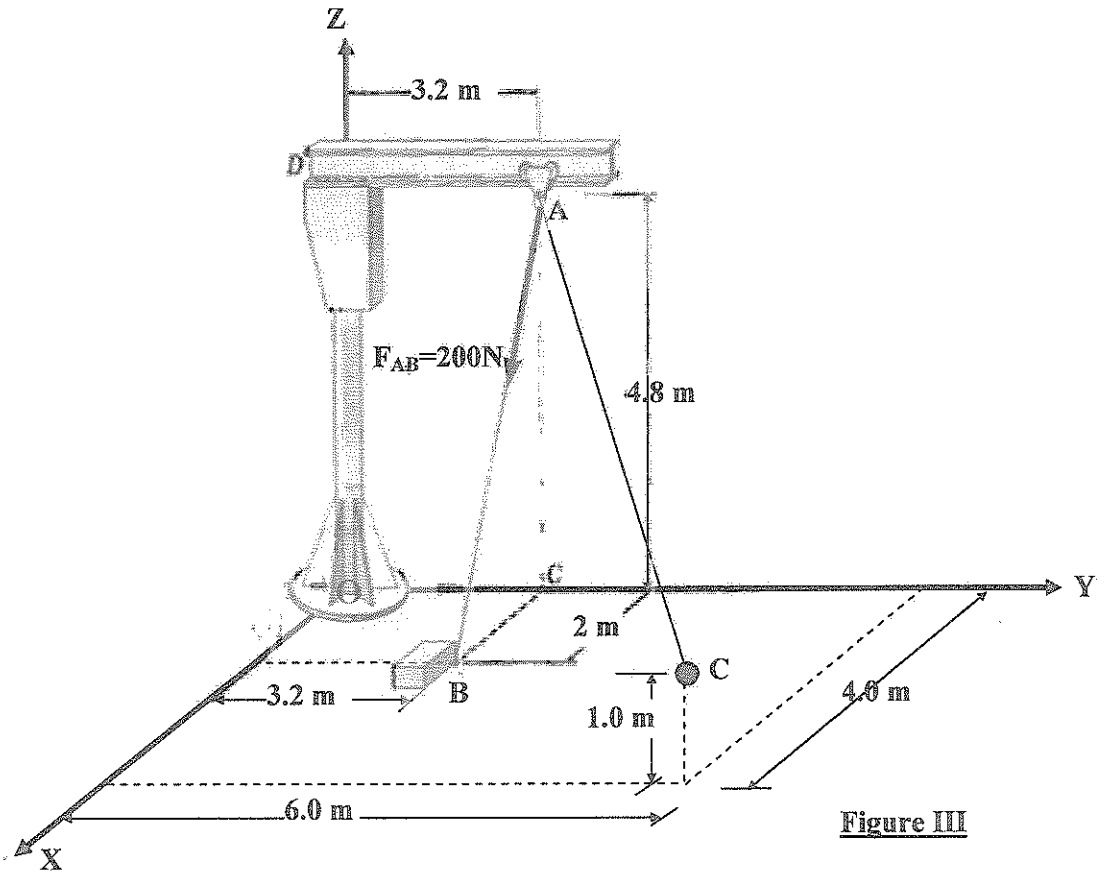


Figure III

For the frame shown in **Figure III**:

1. Determine the projected components of the force F_{AB} parallel and perpendicular to line AC. Express the result in a Cartesian vector form. *(25 points).*
2. Use the Dot Product, determine the angle between F_{AB} and *line AO*. *(10 points).*

Calculations and/or Diagrams:

1. Coordinates: A(0, 3.2, 4.8) B(2, 3.2, 0) C(4, 6, 1)

$$\vec{F}_{AB} = 200\,\vec{u}_{AB} = 200\left\{\frac{2\vec{i}+(3.2-3.2)\vec{j}+(0-4.8)\vec{k}}{\sqrt{(2)^2+(0)^2+(-4.8)^2}}\right\}$$

$$\Rightarrow \vec{F}_{AB} = \{76.92\,\vec{i}+0\vec{j}-184.62\vec{k}\}\,N$$

$$\vec{u}_{AC} = \frac{(4-0)\vec{i}+(6-3.2)\vec{j}+(1-4.8)\vec{k}}{\sqrt{(4)^2+(2.8)^2+(-3.8)^2}} = \{0.647\vec{i}+0.453\vec{j}-0.614\vec{k}\}$$

Calculations and/or Diagrams (cont'd):

$\vec{F}_{AB//AC} = \vec{F}_{AB} \cdot \vec{u}_{AC} = \{76.92\vec{i} + 0\vec{j} - 184.62\vec{k}\} \cdot \{0.647\vec{i} + 0.453\vec{j} - 0.614\vec{k}\}$

$= \{76.92(0.647) + 0 + 184.62(0.614)\}$

$\therefore \boxed{F_{AB//AC} = 163.12\ N}$

In Cartesian vector:

$\vec{F}_{AB//AC} = F_{AB//AC}\,\vec{u}_{AC} = 163.12\{0.647\vec{i} + 0.453\vec{j} - 0.614\vec{k}\}$

$\Rightarrow \boxed{\vec{F}_{AB//AC} = \{105.54\vec{i} + 73.89\vec{j} - 100.16\vec{k}\}}$

$F_{\perp AB} = \sqrt{F_{AB}^2 - F_{AB//AC}^2} = \sqrt{200^2 - 163.12^2}$

$\therefore \boxed{F_{\perp AB} = 115.72\ N}$

In Cartesian form:

$\vec{F}_{\perp AB} = \vec{F}_{AB} - \vec{F}_{AB//AC} = \{76.92\vec{i} + 0\vec{j} - 184.62\vec{k}\} - \{105.54\vec{i} + 73.89\vec{j} - 100.16\vec{k}\}$

$\Rightarrow \boxed{\vec{F}_{\perp AB} = \{-28.62\vec{i} - 73.89\vec{j} - 84.46\vec{k}\}\ N}$

2. $\vec{F}_{AB} \cdot \vec{u}_{AO} = F_{AB}\, u_{AO} \cos\theta$

$\vec{u}_{AO} = \dfrac{0\vec{i} - 3.2\vec{j} - 4.8\vec{k}}{\sqrt{(0)^2 + (-3.2)^2 + (-4.8)^2}} = 0\vec{i} - 0.555\vec{j} - 0.832\vec{k}$

$\{76.92\vec{i} + 0\vec{j} - 184.62\vec{k}\} \cdot \{0\vec{i} - 0.555\vec{j} - 0.832\vec{k}\} = 200(1)\cos\theta$

$\Rightarrow \boxed{\theta = 39.89^\circ}$

EXTRA SHEET 1: Continued from page

Name: _____ **ID#:** _____

Calculations and/or Diagrams:

EXTRA SHEET 2: Continued from page

Name: _____ **ID#:** _____

Calculations and/or Diagrams: