TEST 1
~~Fall 2016~~

(6 October, 2016)

CIE200 – STATICS
CLOSED BOOK, 75 MINUTES

Name: Amer Elsouri **ID#:** Solution **Section:**

NOTES

- 3 problems (10 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:	___/25
Problem II:	___/35
Problem III	___/40
	.....
TOTAL:	/100

Problem I: *(25 points)*

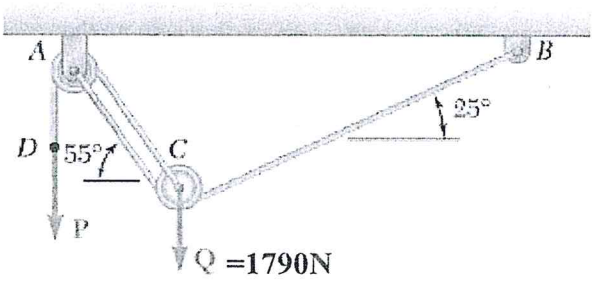


Figure I

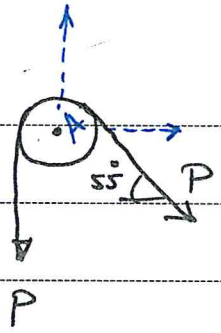
An 1790-N load Q is applied to the pulley C, which can roll on the cable ACB as shown in **Figure I**. The pulley is held in the position shown by a second cable CAD, which passes over the pulley A and supports a load P.

1. Determine the tension in cable ACB, and the magnitude of load P.

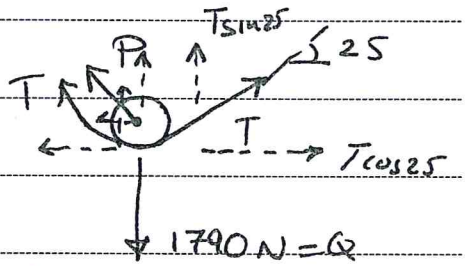
Note: FBD must be included

Calculations and/or Diagrams:

① at "A"



② at C



$\rightarrow \Sigma F_x = 0$

$T\cos 25 - P\cos 55 - T\cos 55 = 0 \quad -(1)$

$0.332T = P\cos 55$

$T = 1.723P \quad -(1)$

$\uparrow \Sigma F_y = 0$

$-1790 + T\sin 25 + P\sin 55 + T\sin 55 = 0.$

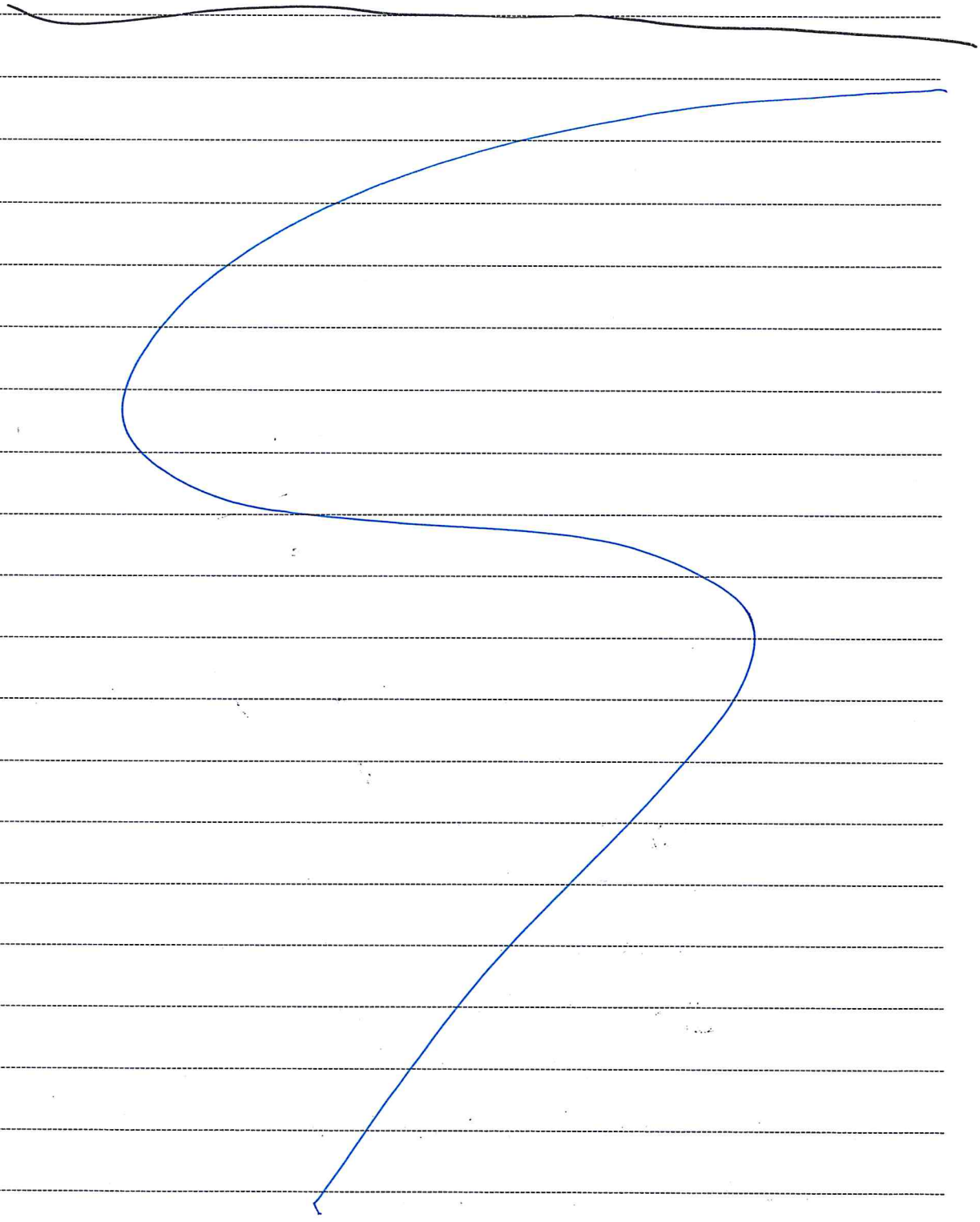
$-1790 + 0.73P + 0.82P + 1.41P = 0.$

Calculations and/or Diagrams:

$2.96\ P = 1790$

$P = 604.4\ N.$

$T = 1042\ N.$



Problem II: *(35 points)*

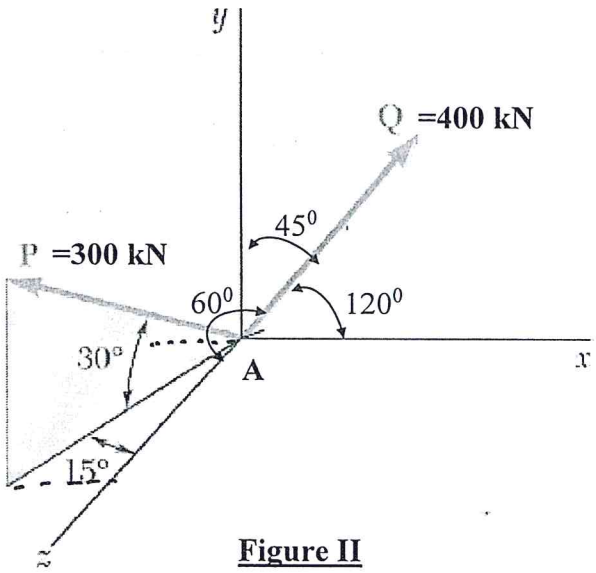


Figure II

For the two forces shown in **Figure II**:

1. Determine the magnitude and direction angles of the resultant force acting at A. Express your result as Cartesian vector. *(15 points)*
2. Determine the angles between ***P*** and ***Q***. *(5 points).*
3. Determine the projected components of the force ***P*** along and perpendicular to **Q**. Express the results as a Cartesian vector. *(15 points).*

Calculations and/or Diagrams:

$\vec{Q} = 400\cos 60\,\vec{k} + 400\cos 120\,\vec{i} + 400\cos 45\,\vec{j}$

$\vec{Q} = 200\vec{k} - 200\vec{i} + 282.84\vec{j}$ (kN)

$\vec{P} = ?$ $\quad P_y = 300\sin 30 = 150$

$P_{x-y} = 300\cos 30 = 260$

$P_x = 260\sin 15 = 67.3$

$P_z = 260\cos 15 = 251.14$

$\vec{P} = -67.3\vec{i} + 150\vec{j} + 251.14\vec{k}$

$\vec{F_R} = -267.3\vec{i} + 432.4\vec{j} + 451.14\vec{k}$

$F_R = \sqrt{267.3^2 + 432.4^2 + 451.14^2} = 679.85$ kN

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Calculations and/or Diagrams (cont'd):

$\alpha = \cos^{-1} \frac{-2673}{679.85} = 113.15^\circ$

$\beta = \cos^{-1} 432.4/679.85 = 50.50.$

$\gamma = \cos^{-1} \frac{451.44}{679.85} = 48.40^\circ$

(2) θ between P & Q

dot product

$\vec{P} \cdot \vec{Q} = P.Q \cos\theta$

$-67.3 \times -200 + 282.84 \times 150 + 251.14 \times 200 = P.Q \cos\theta$

$106114 = 400 \times 300 \cos\theta$

$\cos\theta = 0.884.$ ✓

$\theta = 27.83^\circ$ ✓

(3) $P_Q = \vec{P} \cdot \vec{\mu}_Q$ dot product.

$\vec{\mu}_Q = \cos 120\, \vec{i} + \cos 45\, \vec{j} + \cos 60\, \vec{k}$

$\vec{\mu}_Q = -0.5\, \vec{i} + 0.707\, \vec{j} + 0.5\, \vec{k}$

$P_Q = -67.3(-0.5) + 0.707(150) + 0.5(251.44)$

$P_{//Q} = 265.42 \text{ kN}$

$\vec{P}_{//Q} = 265.42(-0.5\, \vec{i} + 0.707\, \vec{j} + 0.5\, \vec{k})$

$= -132.71\, \vec{i} + 187.65\, \vec{j} + 132.71\, \vec{k}$

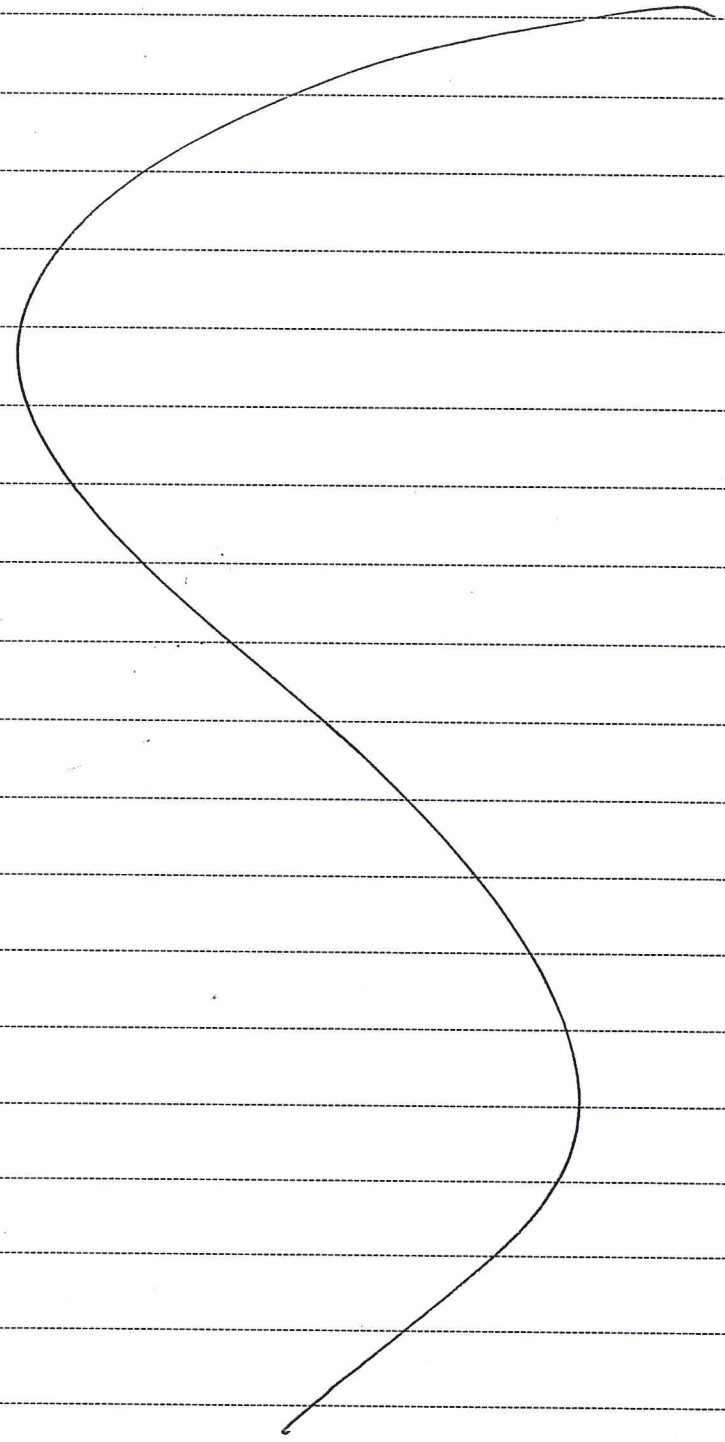
$\vec{P}_{\perp Q} = \vec{P} - P_{// Q} = (-67.3 + 132.71)\, \vec{i} + \vec{j}(150 - 187.$

$+ \vec{k}(251.14 - 132.$

$= 65.41\, \vec{i} - 37.65\, \vec{j} + 118.43\, \vec{k}$

Calculations and/or Diagrams (cont'd):

$P_{\frac{1}{2}}$ to Q = 140.43 kN



Problem III: *(40 points)*

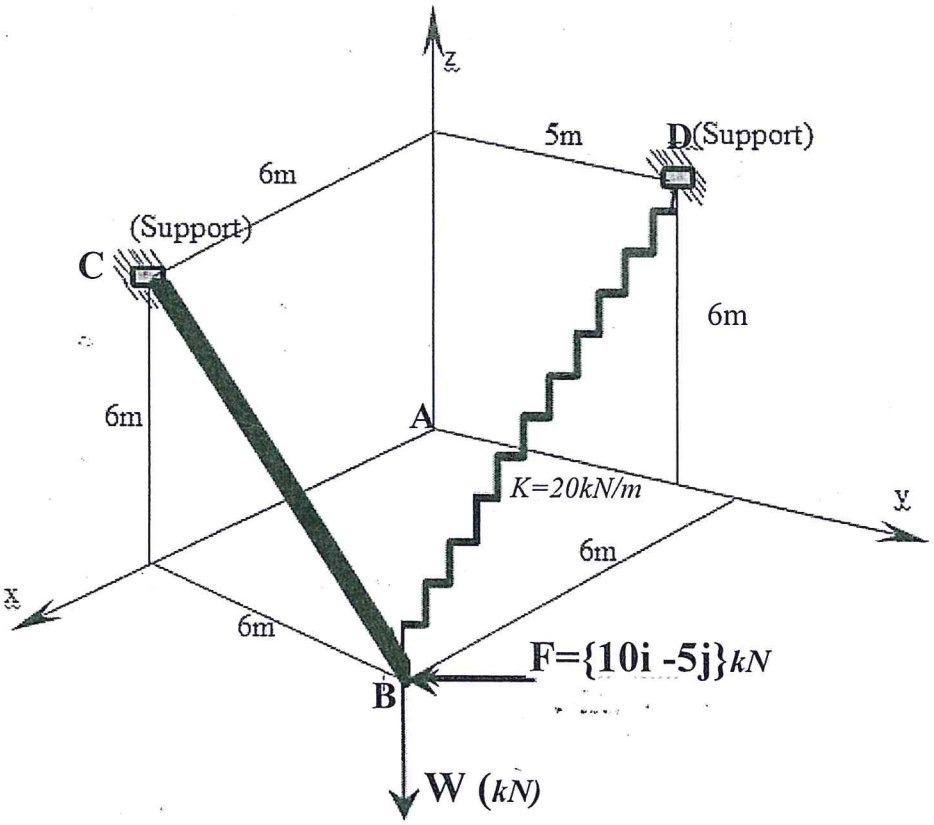


Figure III

The spring/chord system shown in Figure **III** is in equilibrium.

1. Determine the forces in spring ***BD***, chord ***BC*** and the weight ***W*** suspended at ***B***. *(30 points).*
2. What would be the un-stretched length of spring ***BD***? *(10 points).*

Calculations and/or Diagrams:

$A(0,0,0)$, $B(6,6,0)$ $C(6,0,6)$

$D(0,5,6)$.

$\vec{W} = -W\vec{k}$

$\vec{F} = 10\vec{i} - 5\vec{j}$

$\vec{F}_{BD} = F_{BD} \cdot \vec{u}_{BD} = \left(\frac{-6\vec{i} - \vec{j} + 6\vec{k}}{\sqrt{36+1+36}}\right) F_{BD}$ $\rightarrow 8.54$

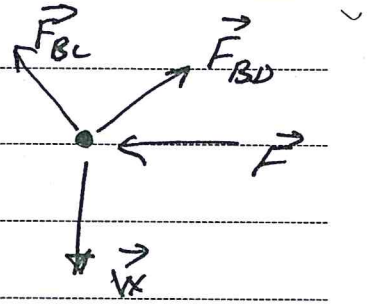
$= -0.702 F_{BD}\vec{i} - 0.117 F_{BD}\vec{j} + 0.702 F_{BD}\vec{k}$

Calculations and/or Diagrams (cont'd):

$$\vec{F}_{BC} = F_{BC} \cdot \vec{u}_{BC} = F_{BC}\left(\frac{0\vec{i} - 6\vec{j} + 6\vec{k}}{\sqrt{72}}\right)$$

$$\vec{F}_{BC} = -0.707 F_{BC}\vec{j} + 0.707 F_{BC}\vec{k}$$

FBD at B



$\Sigma F_x = 0.$ $\quad 10 - 0.702 F_{BD} = 0.$

$F_{BD} = 14.24$ kN (Tension).

$\Sigma F_y = 0$ $\quad -5 - 0.117 F_{BD} - 0.707 F_{BC} = 0$

$F_{BC} = -9.43$ kN (comp).

$\Sigma F_z = 0.$

$0.702 F_{BD} + 0.707 F_{BC} - W = 0.$

$W = +9.996 - 6.66 = 3.33$ kN

Stretch in BD $\Delta = \frac{14.24}{20} = 0.712$ m.

L_{BD} unstretched $= L_{BD} - 0.712 = 8.54 - 0.712$

L_{BD} unstretched $= 7.83$