King Saud University
College of Engineering
Department of Civil Engineering

GE 201 Statics
First Semester 1434-35 H
Monday: 29-1-1435
Time: 90 Min

SECOND MID TERM EXAM
(SOLUTION)

Name (in Arabic): ……..

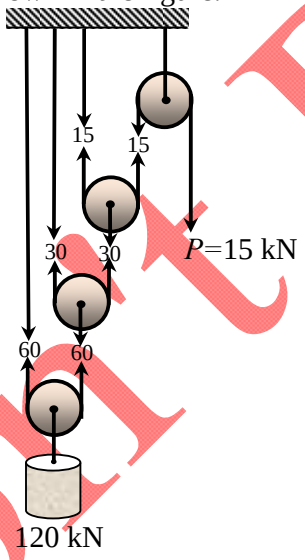
Student No.: ……..

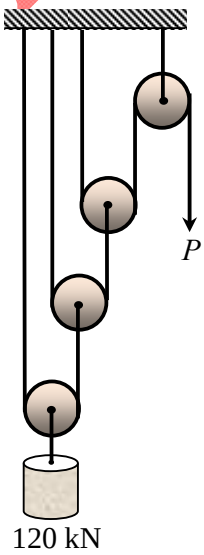
Section / Instructor: ……..

Q. No.	Max. Marks	Marks Obtained
1	10	
2	10	
3	10	
Total	30	

Question # 1(a) (3 Marks)

Calculate the force P required to carry the 120 kN load for equilibrium of the pulley system shown in the figure.





Solution

The free body diagram clearly illustrates that force P for equilibrium of the pulley system is 15 kN. That is,

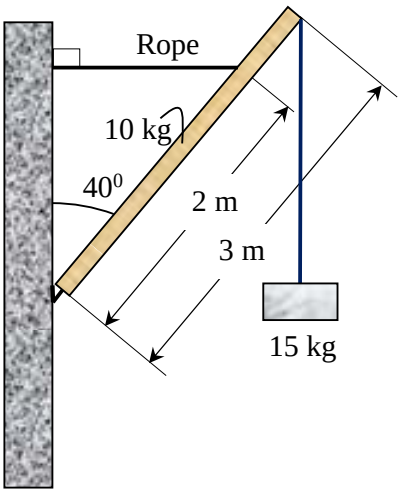
P = 15 kN

Question # 1(b) (3 Marks)

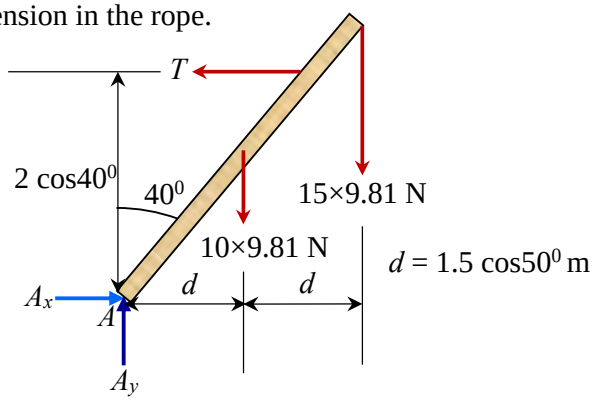
A uniform 10.0 kg beam 3.0 m long is hinged to a wall and supported by a horizontal rope to make a 40º angle with the wall. A 15 kg mass hangs from the end of the beam.

i. Draw Free Body Diagram (FBD) of the beam.

ii. Determine the tension in the rope.



Solution



$CCW(+)\Sigma M_A = 0 \Rightarrow T \times 2\cos 40^0 - 15\times 9.81\times 3\cos 50^0 - 10\times 9.81\times 1.5\cos 50^0 = 0 \Rightarrow \underline{\underline{T = 246.95\ \text{N}}}$ *Ans.*

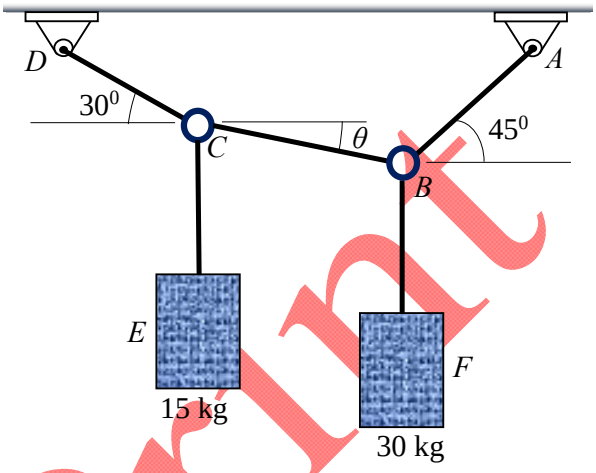
Student name		**Marks obtained for Q.1**	page 2/5
Student number			

Question #1c (4 Marks)

For the equilibrium of the 15-kg cylinder *E* and the 30-kg cylinder *F*

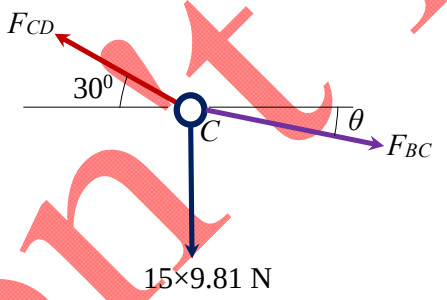
(i) Draw the Free Body Diagram (FBD) of joints *C* and *B*.

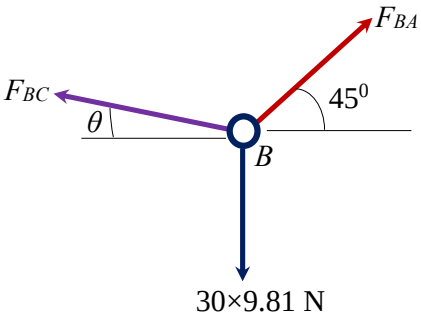
(ii) Determine the tensions developed in wires *CD* and *BA*.



Solution

i) Free body diagram of joints *C* and *B*





ii)

Consider the equilibrium of joint *C*, we have

$\overset{+}{\rightarrow}\Sigma F_x = 0 \Rightarrow F_{BC}\cos\theta - F_{CD}\cos 30^0 = 0$ (1)

$\overset{+}{\uparrow}\Sigma F_y = 0 \Rightarrow -F_{BC}\sin\theta + F_{CD}\sin 30^\circ - 15\times 9.81 = 0$ (2)

Consider the equilibrium of joint *B*, we have

$\overset{+}{\rightarrow}\Sigma F_x = 0 \Rightarrow F_{BA}\cos 45^0 - F_{BC}\cos\theta = 0$ (3)

$\overset{+}{\uparrow}\Sigma F_y = 0 \Rightarrow -F_{BA}\sin 45^0 + F_{BC}\sin\theta - 30\times 9.81 = 0$ (4)

Solving Equations (1) through (4), yields

$\theta = 2.95^0$

$F_{BC} = 280.2$ N

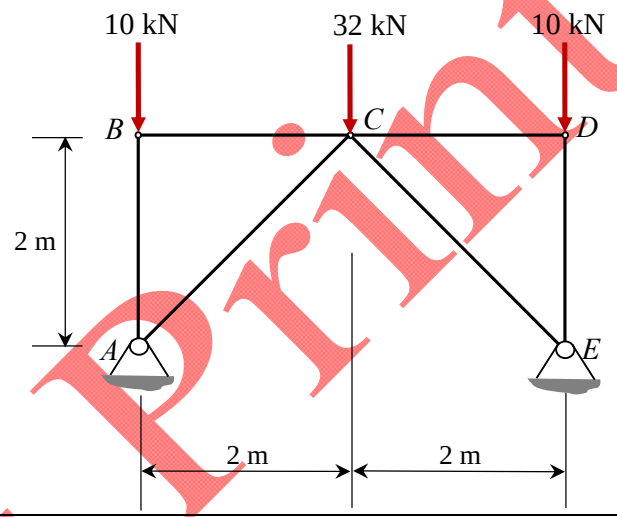
$F_{CD} = 323.2$ N *Ans.*

$F_{BA} = 395.8$ N *Ans.*

Student name		**Marks obtained for Q.2**	page 3/5
Student number			

Question #2a (4 Marks)

Calculate the forces in all the members of the shown truss using *Method of Joints*. Supports at *A* and *E* are pin supports.

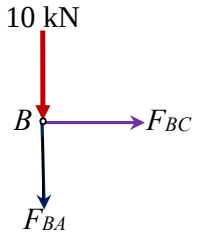


Solution

Consider the equilibrium of joint *B*.

$\overset{+}{\rightarrow}\Sigma F_x = 0 \Rightarrow \underline{\underline{F_{BC} = 0}}$ *Ans.*

$\overset{+}{\uparrow}\Sigma F_y = 0 \Rightarrow -10 - F_{BA} = 0 \Rightarrow \underline{\underline{F_{BA} = -10 \text{ kN (C)}}}$ *Ans.*

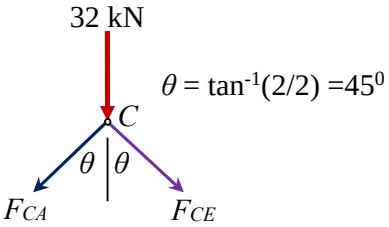


Consider the equilibrium of joint *C*.

$\overset{+}{\rightarrow}\Sigma F_x = 0 \Rightarrow -F_{CA}\sin 45^0 + F_{CE}\sin 45^0 = 0 \Rightarrow F_{CA} = F_{CE}$

$\overset{+}{\uparrow}\Sigma F_y = 0 \Rightarrow -32 - F_{CA}\cos 45^\circ - F_{CE}\cos 45^\circ = 0$

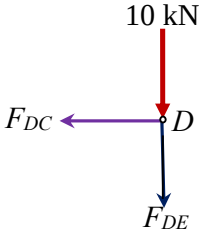
$\Rightarrow -2F_{CA}\cos 45^\circ = 32 \Rightarrow \underline{\underline{F_{CA} = F_{CE} = -22.63 \text{ kN (C)}}}$ *Ans.*



Consider the equilibrium of joint *D*.

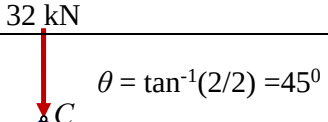
$\overset{+}{\rightarrow}\Sigma F_x = 0 \Rightarrow -F_{DC} = 0 \Rightarrow \underline{\underline{F_{DC} = 0}}$ *Ans.*

$\overset{+}{\uparrow}\Sigma F_y = 0 \Rightarrow -10 - F_{DE} = 0 \Rightarrow \underline{\underline{F_{DE} = -10 \text{ kN (C)}}}$ *Ans.*



Alternative solution

The truss is symmetric with respect to its loading and geometry, and members *BC* and *CD* are zero force members.



$\therefore F_{BC} = F_{CD} = 0$; and $F_{BA} = F_{DE} = -10$ kN (C) *Ans.*

Consider the equilibrium of joint *C*.

$\overset{+}{\uparrow}\Sigma F_y = 0 \Rightarrow -32 - 2F_{CA}\cos 45^\circ = 0 \Rightarrow \underline{\underline{F_{CA} = -22.63 \text{ kN (C)} = F_{CE}}}$ *Ans.*

Student name		**Marks obtained for Q.2**	page 4/5
Student number			

Question#2b(1+2+3 = 6 Marks)

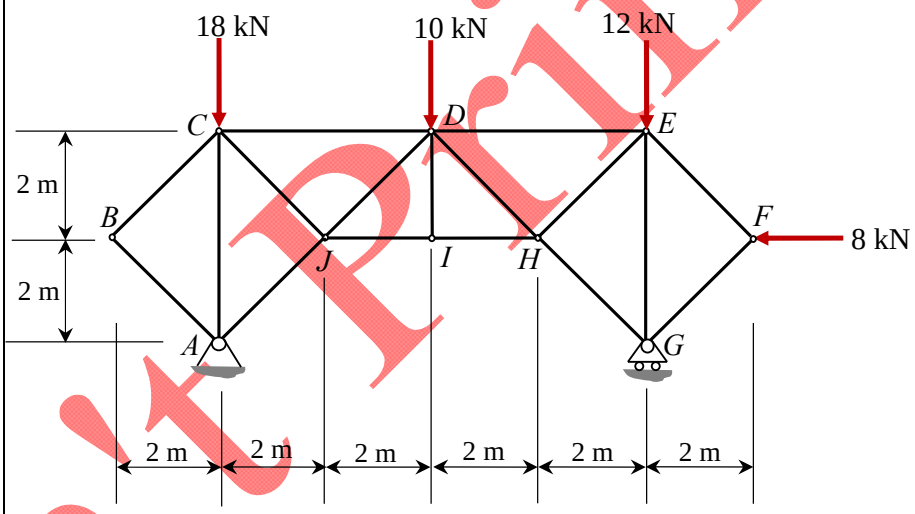
For the truss shown in the figure:

Identify zero force members

i. Identify the zero force members, if any.

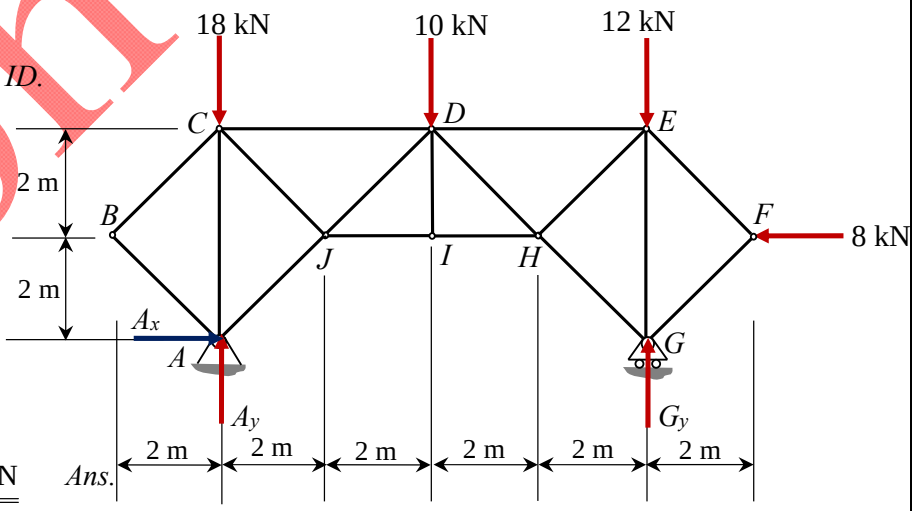
ii. Calculate the support reactions at the supports *A* and *G*. Assume the supports *A* and *G* as pin and roller respectively.

iii. Calculate the forces in the members *DE*, *DH* and *IH* using the method of sections.



Solution

i. *Zero force members*: *BC, BA* and *ID.*



ii. *Reactions:*

$\overset{+}{\rightarrow}\Sigma F_x = 0 \Rightarrow A_x - 8 = 0 \Rightarrow \underline{\underline{A_x = 8 \text{ kN}}}$ *Ans.*

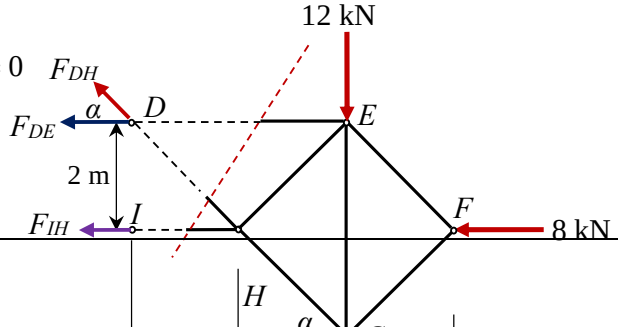
$CCW(+)\Sigma M_A = 0 \Rightarrow G_y \times 8 + 8 \times 2 - 12 \times 8 - 10 \times 4 = 0$

$\Rightarrow G_y \times 8 + 16 - 96 - 40 = 0 \Rightarrow \underline{\underline{G_y = 15 \text{ kN}}} \uparrow$ *Ans.*

$\overset{+}{\uparrow}\Sigma F_y = 0 \Rightarrow A_y + G_y - 18 - 10 - 12 = 0 \Rightarrow A_y + 15 - 40 = 0$

$\Rightarrow \underline{\underline{A_y = 25 \text{ kN}}} \uparrow$ *Ans.*

iii.



$CCW(+)\Sigma M_D = 0 \Rightarrow -F_{IH} \times 2 + 15 \times 4 - 8 \times 2 - 12 \times 4 = 0$

$\Rightarrow \underline{\underline{F_{IH} = -2\,\text{kN (C)}}}$ *Ans.*

$\overset{+}{\uparrow}\Sigma F_y = 0 \Rightarrow 15 - 12 + F_{DH} \sin 45^\circ = 0$

$\Rightarrow \underline{\underline{F_{DH} = -4.24\,\text{kN (C)}}}$ *Ans.*

$\overset{+}{\rightarrow}\Sigma F_x = 0 \Rightarrow -8 - F_{IH} - F_{DE} - F_{DH} \cos 45^\circ = 0$

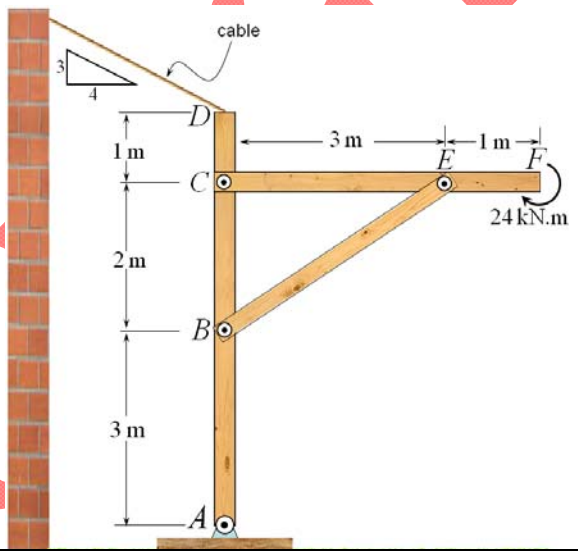
$\Rightarrow -8 - (-2) - F_{DE} - (-4.24)\cos 45^\circ = 0$

$\Rightarrow \underline{\underline{F_{FD} = -3.0\,\text{kN (C)}}}$ *Ans.*

Student name		**Marks obtained for Q.3**	page 5/5
Student number			

Question #3 (10 Marks)

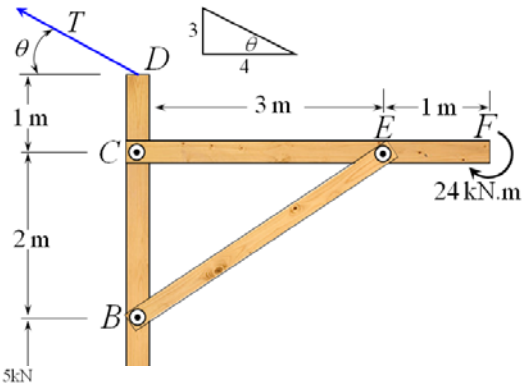
The frame, with a vertical member *ABCD*, a horizontal member *CEF* and an inclined member *BE*, is supported by a cable at *D*. The pin connections are *A*, *B*, *C* and *E*. A moment of 24 kN.m is applied at the point *F*.



(a) Calculate the reaction forces at *A*, and the tension *T* in the cable.
(b) Draw the free body diagrams (*FBD*) for each member.
(c) Determine the horizontal and vertical components of force at *B* and *C*.

Solution

a) Reaction forces at *A*, and the tension *T* in the cable.



$\cos\theta = \frac{4}{5}, \quad \sin\theta = \frac{3}{5}$

Equilibrium equations for the whole frame

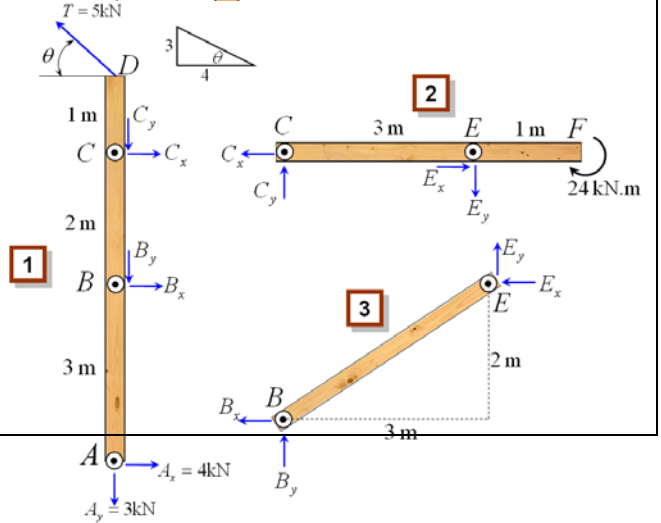
$\rightarrow \sum F_x = 0 \qquad -T\cos\theta + A_x = 0 \qquad (1)$

$\uparrow \sum F_y = 0 \qquad T\sin\theta - A_y = 0 \qquad (2)$

$(ccw+)\sum M_D = 0 \qquad A_x\,(6) - 24 = 0 \qquad (3)$

from (3) $A_x = 4\,\text{kN}$, then from (1) $T = 5\,\text{kN}$, then from (2) $A_y = 3\,\text{kN}$

b) Free Body Diagrams of each member



c) Equilibrium equations for members 1 and 3

Member 1:

$\rightarrow \sum F_x = 0 \qquad 4 + B_x + C_x - 5\cos\theta = 0 \qquad (4)$

$\uparrow \sum F_y = 0 \qquad -3 - B_y - C_y + 5\sin\theta = 0 \qquad (5)$

$(ccw+)\sum M_C = 0 \quad 4(5) + B_x(2) + 5\cos\theta(1) = 0$ (6)

From equation (6), $B_x = -12$ kN (7)

Substituting (7) into (4) yields $C_x = 12$ kN (8)

Member 3:

$(ccw+)\sum M_E = 0 \quad -B_x(2) - B_y(3) = 0$ (9)

Substituting (7) into (9) yields $B_y = 8$ kN (10)

Substituting (10) into (5) yields $C_y = -8$ kN (11)