**Faculté de génie**
**Génie mécanique**

uOttawa
L'Université canadienne
Canada's university

**Faculty of Engineering**
**Mechanical Engineering**

# GNG1505 - MÉCANIQUE POUR INGÉNIEURS

Examen de reprise
Février, 2011
Profs. Haddad et Milane

Durée: 3 heures


**Livre Fermé**. Calculatrices non-programmables seulement sont permises. Diagrammes des corps libres doivent être dessinés si nécessaire. Des notes vont être déduites si les diagrammes des corps libres sont incomplets ou manquants.

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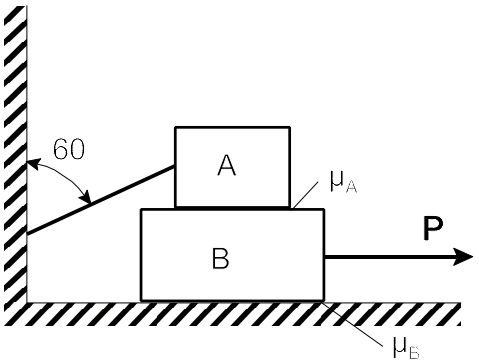
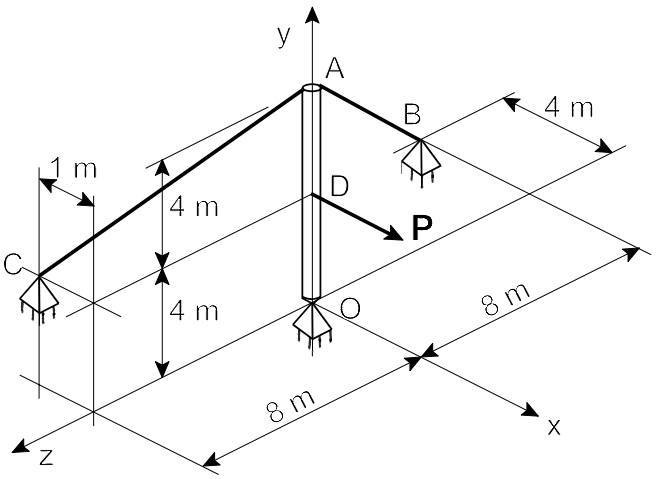
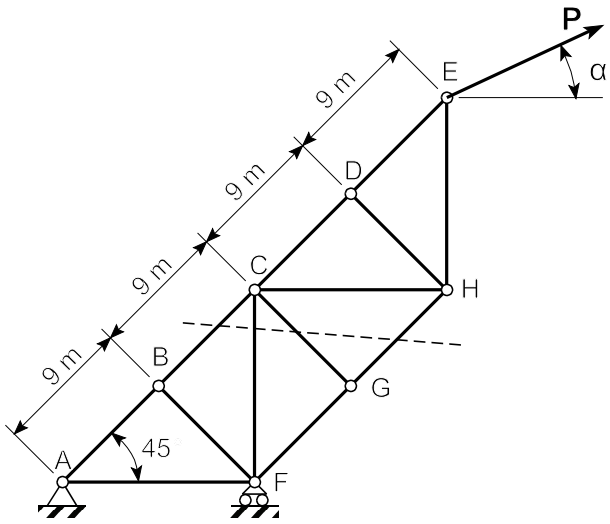
1. (12 notes) Le bloc A du schéma a une masse de 20 kg et est attaché au mur à l'aide d'une corde ayant un angle de 60° avec la verticale, tandis que le bloc B a une masse de 40 kg. Le coefficient de frottement statique entre A et B est $\mu_{SA} = 0.20$, tandis que le coefficient de frottement statique entre B et le sol est $\mu_{SB} = 0.30$. Déterminez la force minimale requise pour que le bloc B glisse.



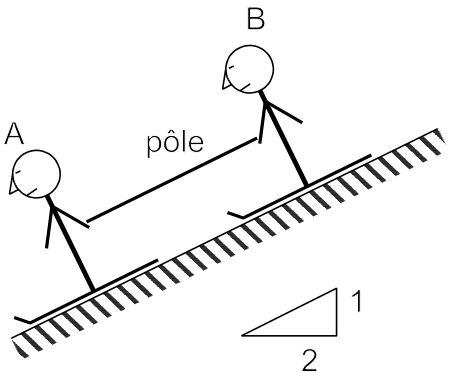

2. (12 notes) Un mât s'appuie sur une rotule en O et par deux câbles AB et AC. Déterminez les tensions dans les deux câbles si la force appliquée est P = 20 kN. Le point B est dans le plan x-z, tandis que le point C est à 4 m au-dessus du plan x-z.



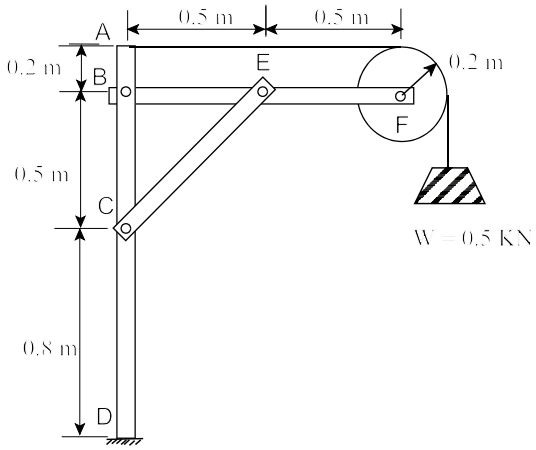
3. (12 notes) Le schéma montre un treillis soumis à une force **P**. En supposant que les noeuds sont des pivots:
(a) Identifiez les barres à effort nul.
(b) Si la force dans la barre GH est 0.6 kN sous compression, et la force dans la barre BC est 4.8 kN sous tension, calculez les valeurs de P et de l'angle α.
**Suggestion**: Utilisez une section qui coupe les barres BC, CF, CG et GH.
Relation trigonométrique:
$\sin(\theta \pm \varphi) = \sin\theta\cos\varphi \pm \cos\theta\sin\varphi$
$\cos(\theta \pm \varphi) = \cos\theta\cos\varphi \pm \sin\theta\sin\varphi$




4. (12 notes) Deux skieurs, A et B, glissent sur une piste de pente 1:2. Le skieur A a une masse de 60 kg et B une masse de 80 kg. Du à la différence de cirage des skis, les coefficients de frottement sont différents: le skieur A a un coefficient $\mu_{KA} = 0.10$, tandis que B a $\mu_{KB} = 0.20$. Les skieurs sont reliés par un pôle de ski. Négligez le poids du pôle, et supposez que les connections du pôle avec les mains des skieurs sont des pivots.
(a) Calculez la force dans le pôle (specifiez si il est sous tension ou compression).
(b) Déterminez l'accélération des skieurs.
(c)Si la vitesse initiale des skieurs est de 10 m/s, déterminez la vitesse des skieurs aprés avoir glissé 100 m de la position initiale.




5. (12 notes) Le croquis montre une structure soumise à un poids W=0.5 KN.
a) Calculez les composantes de la réaction au support fixe D.
b) Calculez les composantes des forces agissantes aux pivots B, C et E.



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Civil Engineering

# GNG 1105 – ENGINEERING MECHANICS

Supplemental Examination
February, 2011.

Time: 3 hrs.

Profs. Skaff, Van Blaeren and Flores-Vera.



**Closed Book Examination.** Programmable calculators are not allowed.

Free-body diagrams must be drawn wherever appropriate.

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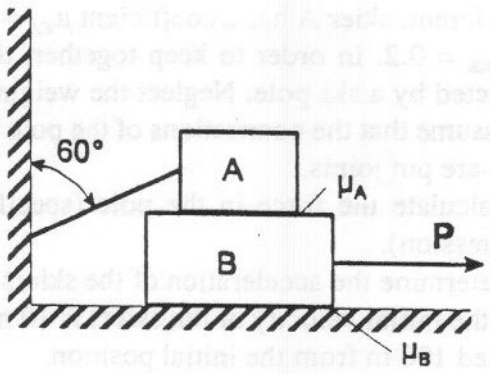
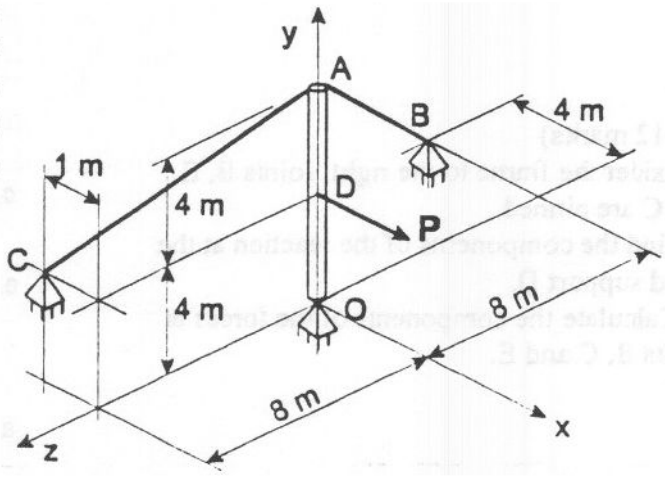
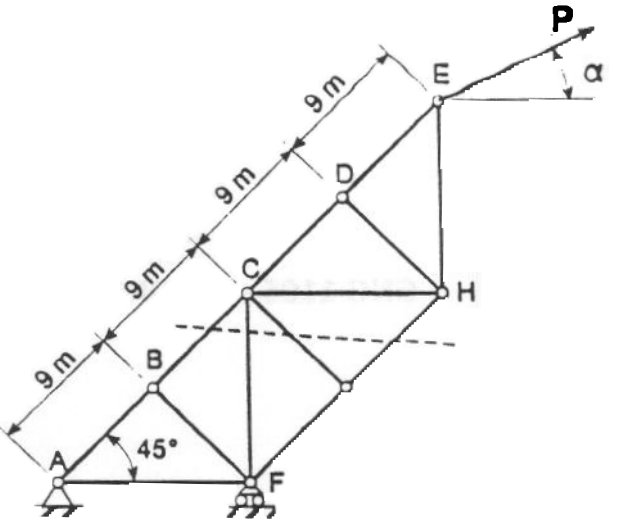
1. **(12 marks) Block A in the sketch has a mass of 20 kg and is attached to the wall by means of a cord at an angle of 60° to the vertical, while Block B has a mass of 40 kg. The static friction coefficient between A and B is $\mu_{SA}$ = 0.2, while the static friction coefficient between B and the floor is $\mu_{SB}$ = 0.3. Determine the minimum force P required to cause Block B to slide.**



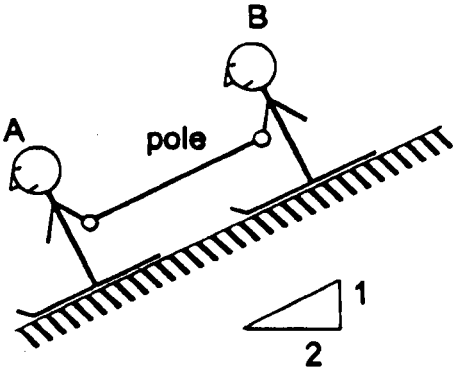

2. (12 marks) A mast is supported by a frictionless ball and socket joint at O and by two cables AB and AC. Determine the tensions in the two cables if the applied load P = 20 kN. Point B lies in the x-z plane, while point C lies 4 m above the x-z plane.



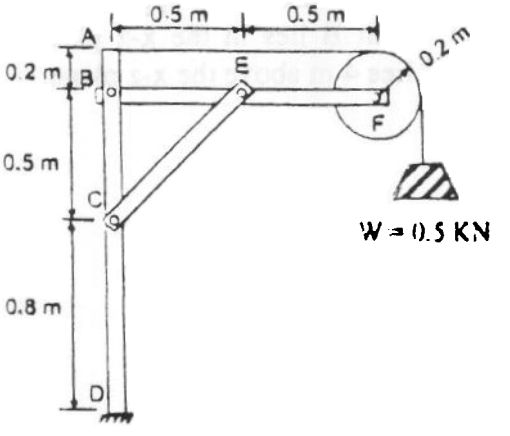
3. (12 marks) The sketch shows a pin-jointed truss, loaded with a single force **P** as shown.
(a) Identify all zero-force members.
(b) If the force in member GH is 0.6 kN in compression, and the force in member BC is 4.8 kN in tension, calculate the values of P and the angle α. **Hint**: use a section that cuts members BC, CF, CG and GH.
Trigonometric identities:
$\sin(\theta \pm \phi) = \sin\theta\cos\phi \pm \cos\theta\sin\phi$
$\cos(\theta \pm \phi) = \cos\theta\cos\phi \mp \sin\theta\sin\phi$




4. (12 marks) Two skiers, A and B, are skiing down a 1:2 slope. Skier A has a mass of 60 kg and B a mass of 80 kg. Owing to differences in ski wax, the friction coefficients are different: skier A has a coefficient $\mu_{KA} = 0.1$, while B has $\mu_{KB} = 0.2$. In order to keep together, the skiers are connected by a ski pole. Neglect the weight of the pole, and assume that the connections of the pole to the skiers' hands are pin joints.
(a) Calculate the force in the pole (specify tension or compression).
(b) Determine the acceleration of the skiers.
(c) If the initial velocity of the skiers is 10 m/s, determine the velocity of the skiers after they have traveled 100 m from the initial position.




5. (12 marks)
Consider the frame to the right. Joints B, E and C are pinned.
a) Find the components of the reaction at the fixed support D.
b) Calculate the components of the forces at joints B, C and E.



# GNG 1105

Feb, 2011

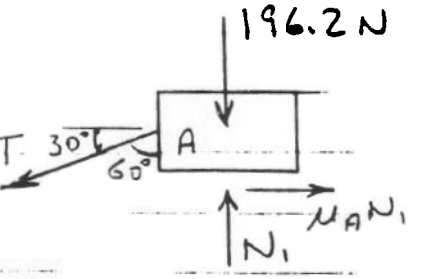
## ENGINEERING MECHANICS

## SUPPLEMENTAL EXAM

## SOLUTIONS

1. FBD - Block A

$20\ kg \times 9.81 = 196.2\ N$




$+\uparrow \Sigma F_y = 0,$

$N_1 - T\cos 60° - 196.2 = 0$

$N_1 - 0.5T - 196.2 = 0$ ——— (1)

$\pm\rightarrow \Sigma F_x = 0,$

$\mu_A N_1 - T\sin 60° = 0$

$0.2N_1 - 0.866T = 0$ ——— (2)

Multiply (1) by 0.866 and (2) by 0.5 and subtract:

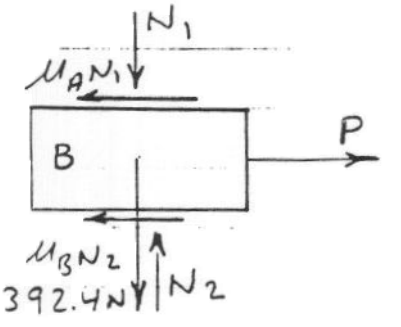
$0.866N_1 - 0.433T - 169.91 - 0.1N_1 + 0.433T = 0$

$0.866N_1 - 0.1N_1 = 169.91$

$0.766N_1 = 169.91$ ; $\therefore N_1 = \underline{221.81\ N}$

FBD - Block B

$40\ kg \times 9.81 = 392.4\ N$




$+\uparrow \Sigma F_y = 0,$

$N_2 - N_1 - 392.4 = 0$

$N_2 = 392.4 + 221.81 = \underline{614.21\ N}$

$\pm\rightarrow \Sigma F_x = 0;$

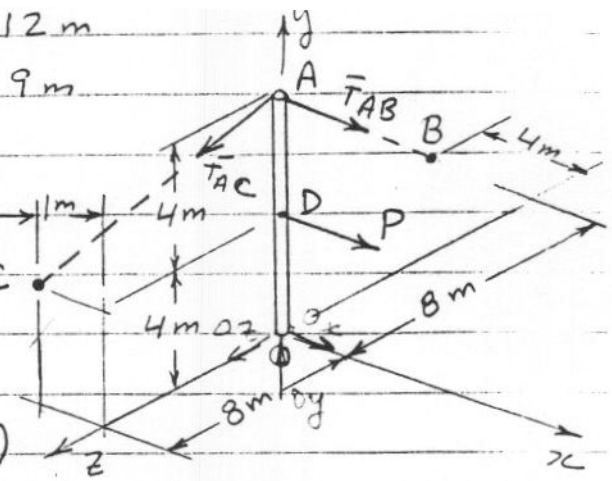
$P - \mu_A N_1 - \mu_B N_2 = 0$

$P - 0.2 \times 221.81 - 0.3 \times 614.21 = 0;$ $\therefore P = \underline{228.62\ N}$ ANS.

2

$\bar{AB} = -4\bar{i} - 8\bar{j} - 8\bar{k}$ ; $\therefore AB = 12\,m$

$\bar{AC} = -1\bar{i} - 4\bar{j} + 8\bar{k}$ ; $\therefore AC = 9\,m$




$\bar{T}_{AB} = T_{AB}\dfrac{\bar{AB}}{AB} = \dfrac{T_{AB}}{12}(-4\bar{i} - 8\bar{j} - 8\bar{k})$

$\bar{T}_{AC} = T_{AC}\dfrac{\bar{AC}}{AC} = \dfrac{T_{AC}}{9}(-1\bar{i} - 4\bar{j} + 8\bar{k})$

$\Sigma \bar{M}_O = 0$

$= (\bar{r}_{OA} \times \bar{T}_{AB}) + (\bar{r}_{OA} \times \bar{T}_{AC}) + (\bar{r}_{OD} \times P)$

$= 0$

where $\bar{r}_{OA} = 8\bar{j}$ ; $\bar{r}_{OD} = 4\bar{j}$ ; $P = 20\bar{i}\,kN$

$\therefore 8\bar{j} \times \dfrac{T_{AB}}{12}(-4\bar{i} - 8\bar{j} - 8\bar{k}) + 8\bar{j} \times \dfrac{T_{AC}}{9}(-1\bar{i} - 4\bar{j} + 8\bar{k}) + 4\bar{j} \times 20\bar{i} =$

$\dfrac{32}{12}T_{AB}\bar{k} - \dfrac{64}{12}T_{AB}\bar{i} + \dfrac{8}{9}T_{AC}\bar{k} - \dfrac{64}{9}T_{AC}\bar{i} - 80\bar{k} = 0$

$\left(\dfrac{32}{12}T_{AB} + \dfrac{8}{9}T_{AC} - 80\right)\bar{k} - \left(\dfrac{64}{12}T_{AB} - \dfrac{64}{9}T_{AC}\right)\bar{i} = 0$

Coeff of $\bar{i}$ : $\dfrac{64}{9}T_{AC} - \dfrac{64}{12}T_{AB} = 0$ ——— (1)

Coeff of $\bar{k}$ : $\dfrac{8}{9}T_{AC} + \dfrac{32}{12}T_{AB} - 80 = 0$ ——— (2)

Multiply (2) by 2 and add to (1)

$\dfrac{64}{9}T_{AC} + \dfrac{16}{9}T_{AC} - 160 = 0$

$\dfrac{80}{9}T_{AC} = 160$ ; $\therefore \underline{\underline{T_{AC} = 18\,kN}}$ ANS.

Insert in (1)

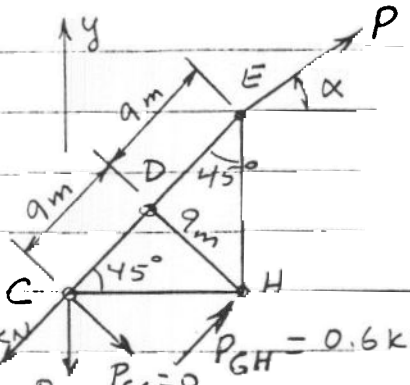
$\dfrac{64}{9} \times 18 - \dfrac{64}{12}T_{AB} = 0$ ; $\therefore \underline{\underline{T_{AB} = 24\,kN}}$ ANS.

3.

a) Zero-Force members are:

BF, CG and DH.

b) FBD – Section shown:




$\curvearrowleft +) \Sigma M_C = 0$ :

$P\sin\alpha(2\times 9\cos 45°) - P\cos\alpha(2\times 9\times\sin 45°) + 0.6\times 9 = 0$

$12.73\,P\sin\alpha - 12.73\,P\cos\alpha + 5.4 = 0$

i.e. $P\sin\alpha - P\cos\alpha = -0.424$ ——— (1)

$\rightarrow +\ \Sigma F_x = 0$ ;

$P\cos\alpha - 4.8\cos 45° + 0.6\cos 45° = 0$

$P\cos\alpha = 3.394 - 0.424$

$P\cos\alpha = 2.970$ ——— (2)

Substituting (2) in (1) :

$P\sin\alpha - 2.970 = -0.424$

and $P\sin\alpha = 2.546$ ——— (3)

Divide (3) by (2):

$\frac{\sin\alpha}{\cos\alpha} = \frac{2.546}{2.970} = \tan\alpha$ ; $\therefore \alpha = 40.60°$ AN

From (2):

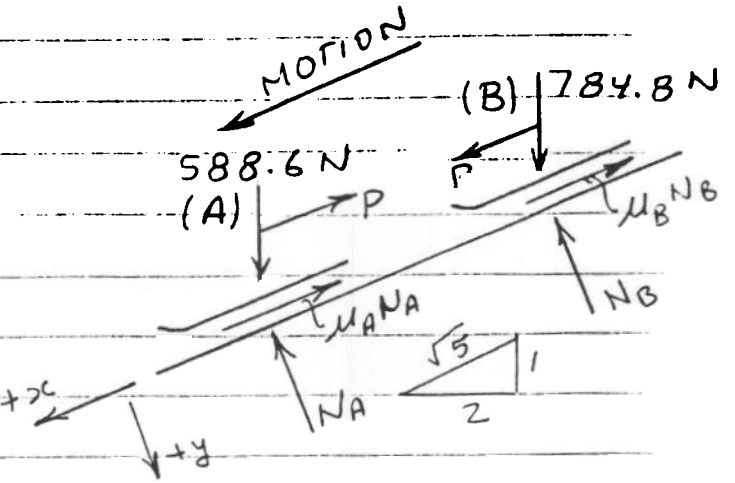
$P\cos 40.60° = 2.970$

$\therefore P = 3.91$ kN AN

4.

$60\,kg \times 9.81 = 588.6\,N$

$80\,kg \times 9.81 = 784.8\,N$




FB_ Skier A

$+\downarrow \Sigma F_y = m a_y = 0$

$588.6 \times \frac{2}{\sqrt{5}} - N_A = 0$

$\therefore N_A = 526.5\,N$

$+\swarrow \Sigma F_x = m a_x$

$-P - \mu_A N_A + 588.6 \times \frac{1}{\sqrt{5}} = 60a$

$-P - 0.1 \times 526.5 + 263.2 = 60a$

$210.6 - P = 60a$ ——— (1)

FB_ Skier B

$+\downarrow \Sigma F_y = m a_y = 0$

$784.8 \times \frac{2}{\sqrt{5}} - N_B = 0$ ; $\therefore N_B = 701.9$

$+\swarrow \Sigma F_x = m a_x$

$P - \mu_B N_B + 784.8 \times \frac{1}{\sqrt{5}} = 80a$

$P - 0.2 \times 701.9 + 784.8 \times \frac{1}{\sqrt{5}} = 80a$

$P + 210.6 = 80a$ ——— (2)

add (1) & (2):

b) $140a = 421.2$ ; $\therefore a = 3\,m/s^2$ ANS

Insert in (1):

a) $210.6 - P = 60 \times 3$ ; $\therefore P = 30.6\,N\,(T)$ ANS

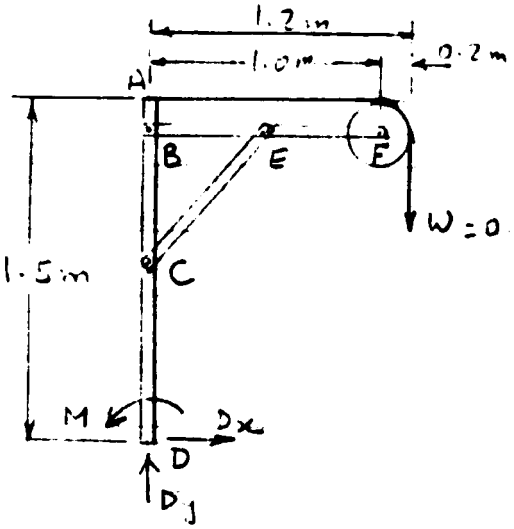
c) $v^2 = v_0^2 + 2a(x - x_0)$

$v^2 = (10)^2 + 2 \times 3\,(100 - 0)$

$v^2 = 100 + 600 = 700$ ; $\therefore v = 26.5\,m/s$ ANS

5.

a) FBD – Entire frame




$+\circlearrowleft \Sigma M_D = 0$

$M - 0.5\,KN \times 1.2\,m = 0$

$\therefore M = 0.6\,KN.m \circlearrowleft$ ANS

$\rightarrow \Sigma F_x = 0$

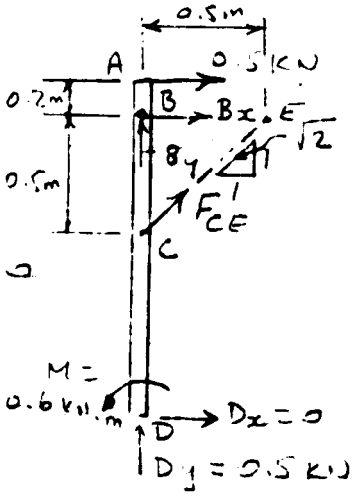
$D_x = 0$ ANS

$+\uparrow \Sigma F_y = 0$

$D_y - 0.5\,KN = 0$, $\therefore D_y = 0.5\,KN \uparrow$ ANS.

b) FBD – member ABCD

CE is a 2-force member.




$+\circlearrowleft \Sigma M_B = 0$

$-0.5\,KN \times 0.2\,m + F_{CE} \times \frac{1}{\sqrt{2}} \times 0.5\,m + 0.6\,KN.m = 0$

$-0.1\,KN.m + 0.35\,F_{CE} + 0.6\,KN.m = 0$

$0.35\,F_{CE} = -0.5$

$F_{CE} = -\frac{0.5}{0.35} = -1.43\,KN$ ANS.

Since CE is a 2-force member, $\therefore F_{EC} = 1.43\,KN \nearrow$ ANS

$\rightarrow \Sigma F_x = 0$

$B_x + 0.5\,KN - 1.43 \times \frac{1}{\sqrt{2}} = 0$

$B_x + 0.5 - 1.01 = 0$ $\therefore B_x = 0.51\,KN \rightarrow$ ANS

$+\uparrow \Sigma F_y = 0$

$B_y + 0.5\,KN - 1.43 \times \frac{1}{\sqrt{2}} = 0$

$B_y + 0.5 - 1.01 = 0$ $B_y = 0.51\,KN \uparrow$

END