

GNUG1105A4E
ENGINEERING MECHANICS

FINAL EXAM

Dec. 11, 2013

SOLUTIONS

1. a)

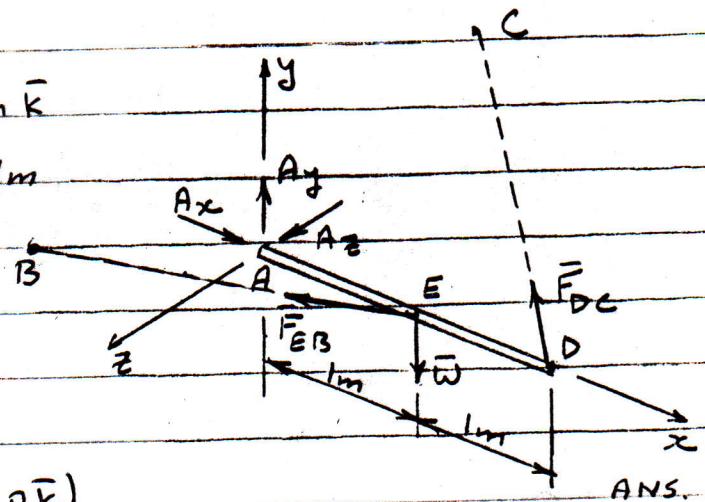
FBD - Rod AD

$$\vec{EB} = -1.0\text{m}\vec{i} + 2.0\text{m}\vec{j} + 3.0\text{m}\vec{k}$$

$$EB = \sqrt{(-1)^2 + (2)^2 + (3)^2} = 3.74\text{m}$$

$$\vec{DC} = -2.0\text{m}\vec{i} + 2.0\text{m}\vec{j} - 3.0\text{m}\vec{k}$$

$$DC = \sqrt{(-2)^2 + (2)^2 + (-3)^2} = 4.12\text{m}$$



$$\begin{aligned}\vec{F}_{EB} &= F_{EB} \lambda_{EB} = F_{EB} \frac{\vec{EB}}{EB} \\ &= \frac{F_{EB}}{3.74} (-1.0\vec{i} + 2.0\vec{j} + 3.0\vec{k})\end{aligned}$$

$$\begin{aligned}\vec{F}_{DC} &= F_{DC} \lambda_{DC} = F_{DC} \frac{\vec{DC}}{DC} \\ &= \frac{F_{DC}}{4.12} (-2.0\vec{i} + 2.0\vec{j} - 3.0\vec{k})\end{aligned}$$

$$b) \sum \vec{M}_A = \vec{r}_{E/A} \vec{F}_{E/B} + \vec{r}_{D/A} \vec{F}_{D/C} + \vec{r}_{E/A} \vec{W} = 0,$$

$$\text{where } \vec{r}_{E/A} = +1.0\text{m}\vec{i} \text{ and } \vec{r}_{D/A} = +2.0\text{m}\vec{i}$$

$$\begin{aligned}\therefore \sum \vec{M}_A &= 1.0\vec{i} \times \frac{F_{EB}}{3.74} (-1.0\vec{i} + 2.0\vec{j} + 3.0\vec{k}) \\ &\quad + 2.0\vec{i} \times \frac{F_{DC}}{4.12} (-2.0\vec{i} + 2.0\vec{j} - 3.0\vec{k}) + 1.0\vec{i} \times (-1.2\text{KN}\vec{j}) = 0\end{aligned}$$

$$\text{Hence, } \sum \vec{M}_A = 0.53 F_{EB} \vec{k} - 0.80 F_{EB} \vec{j} + 0.97 F_{DC} \vec{k} + 1.46 F_{DC} \vec{j} - 1.2 \vec{k} = 0$$

Equate coefficients of \vec{j} and \vec{k} to zero.

$$\textcircled{j} : -0.80 F_{EB} + 1.46 F_{DC} = 0 \quad \text{--- (1)}$$

$$\textcircled{k} : 0.53 F_{EB} + 0.97 F_{DC} - 1.2 = 0 \quad \text{--- (2)}$$

Multiply (1) by 0.53 and (2) by 0.8 and add

$$2.92 F_{DC} - 1.81 = 0; \quad \therefore F_{DC} = \underline{0.62 \text{ KN}}$$

$$\text{Insert in (1) : } -0.80 F_{EB} + 1.46 \times 0.62 = 0; \quad \therefore F_{EB} = \underline{1.13 \text{ KN}}$$

ANS.

ANS

2. a)

FBD - Entire truss

$$\uparrow \sum M_A = 0$$

$$5 \text{ kN} \times 6 \text{ m} + 8 \text{ kN} \times 3 \text{ m} - T_{HB} \times \frac{3}{3.16} \times 4 \text{ m}$$

$$- T_{HB} \times \frac{1}{3.16} \times 9 \text{ m} = 0$$

$$30.00 + 24.00 - 3.80 T_{HB} - 2.85 T_{HB} = 0$$

$$6.65 T_{HB} = 54.00$$

$$\therefore T_{HB} = \underline{\underline{8.12 \text{ kN}}}$$

$$\rightarrow \sum F_x = 0$$

$$A_x + 8.12 \times \frac{3}{3.16} = 0, \therefore A_x = \underline{\underline{-7.71 \text{ kN}}}$$

$$\uparrow \sum F_y = 0$$

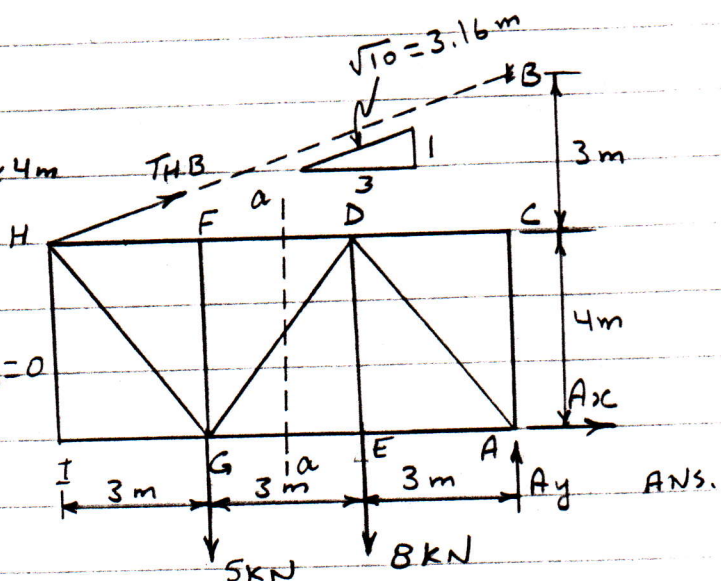
$$A_y + 8.12 \times \frac{1}{3.16} - 5 - 8 = 0$$

$$A_y = 5 + 8 - 2.57 = \underline{\underline{10.43 \text{ kN}}}$$

$$\therefore A = \sqrt{(-7.71)^2 + (10.43)^2} = 12.97 \text{ kN}; \theta = \tan^{-1} \frac{10.43}{-7.71} = 53.53^\circ$$

$$\therefore A = \underline{\underline{12.97 \text{ kN}}}$$

$$\begin{array}{l} 12.97 \text{ kN} \\ 53.53^\circ \end{array} \quad \text{ANS.}$$



b) FBD - section right of aa.

$$\uparrow \sum M_D = 0$$

$$10.43 \times 3 - 7.71 \times 4 - F_{EG} \times 4 = 0$$

$$4 F_{EG} = 31.29 - 30.84 = 0$$

$$\therefore F_{EG} = 0.11 \text{ kN (T)}$$

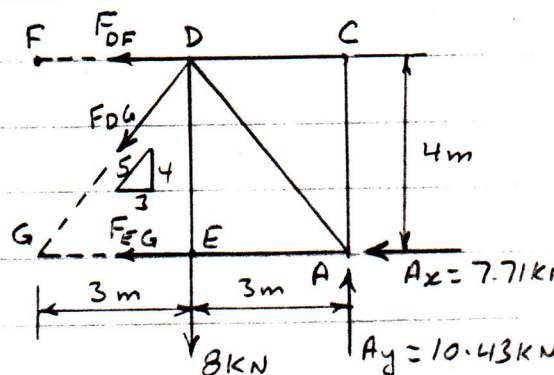
$$\uparrow \sum M_G = 0$$

$$10.43 \times 6 - 8 \times 3 + F_{DF} \times 4 = 0; \therefore F_{DF} = -\frac{38.58}{4} = -9.65 \text{ kN} = 9.65 \text{ kN (C)}$$

$$\uparrow \sum F_y = 0; -F_{DG} \times \frac{4}{5} - 8 \text{ kN} + 10.43 \text{ kN} = 0; \frac{4}{5} F_{DG} = 2.43 \text{ kN}$$

$$\therefore F_{DG} = 3.04 \text{ kN (T)}$$

$$\text{Hence, } F_{FD} = \underline{\underline{9.65 \text{ kN (C)}}}; F_{GD} = \underline{\underline{3.04 \text{ kN (T)}}}; F_{GE} = \underline{\underline{0.11 \text{ kN (T)}}} \quad \text{ANS.}$$



3.

a) See Diagram

b) Link BD is a 2-Force member.

FBD - Lever ABC

$$\uparrow \sum M_C = 0$$

$$F_{DB} \times \frac{3}{5} \times 400 \text{ mm} + F_{DB} \times \frac{4}{5} \times 250 \text{ mm}$$

$$+ 500 \text{ N} \times 1200 \text{ mm} = 0$$

$$240 F_{DB} + 200 F_{DB} + 600000 = 0$$

$$440 F_{DB} = -600000$$

$$\therefore F_{DB} = \underline{\underline{-1363.64 \text{ N}}}$$

ANS.

$$\rightarrow \sum F_x = 0$$

$$C_x + 1363.64 \times \frac{3}{5} - 500 \text{ N} = 0$$

$$\therefore C_x = -318.18 \text{ N}$$

$$\uparrow \sum F_y = 0$$

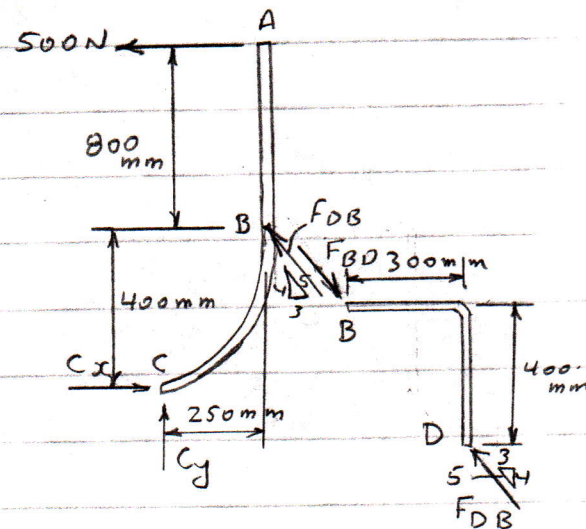
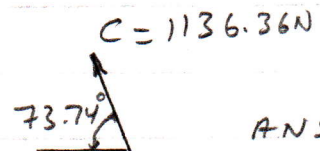
$$C_y - 1363.64 \times \frac{4}{5} = 0$$

$$\therefore C_y = 1090.91 \text{ N}$$

$$\therefore C = \sqrt{(-318.18)^2 + (1090.91)^2} = 1136.36 \text{ N}$$

$$\theta = \tan^{-1} \frac{1090.91}{-318.18} = 73.74^\circ$$

$$\therefore C = \underline{\underline{1136.36 \text{ N}}}$$



4.

FBD - Block A & Block B

$$\text{Weight of block A} = W_A = 20 \times 9.81 = 196.2 \text{ N}$$

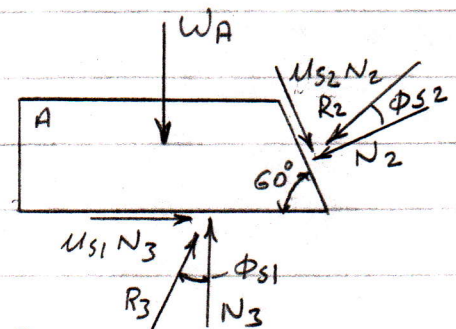
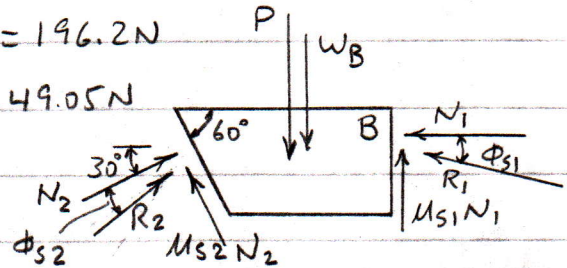
$$\text{Weight of block B} = W_B = 5 \times 9.81 = 49.05 \text{ N}$$

$$\phi_{s1} = \tan^{-1} \mu_{s1}$$

$$\phi_{s1} = \tan^{-1} 0.3 = \underline{16.70^\circ}$$

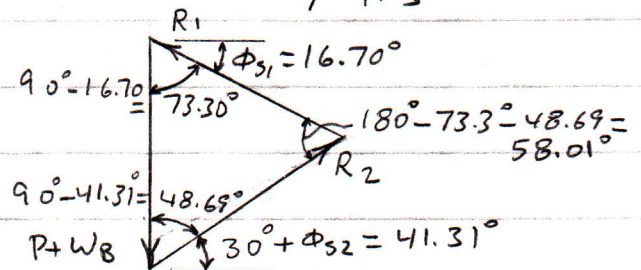
$$\phi_{s2} = \tan^{-1} \mu_{s2}$$

$$\phi_{s2} = \tan^{-1} 0.2 = \underline{11.31^\circ}$$

Force triangle: Block B

$$\frac{R_2}{\sin 73.30^\circ} = \frac{P + W_B}{\sin 58.01^\circ}$$

$$R_2 = 1.129P + 55.388 \quad \text{--- (1)}$$

Force triangle: Block A

$$\frac{W_A}{\sin 31.99^\circ} = \frac{R_2}{\sin 16.70^\circ}$$

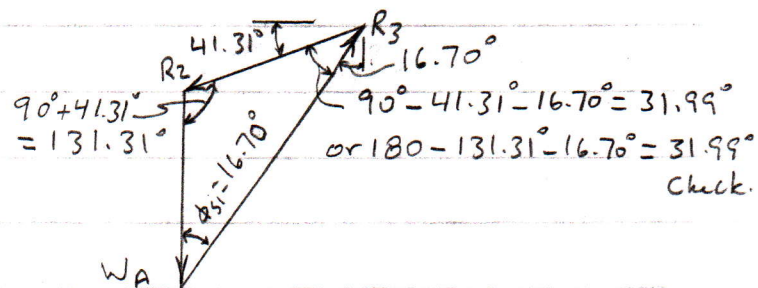
Insert R_2 from eq. (1):

$$\frac{196.2}{\sin 31.99^\circ} = \frac{1.129P + 55.388}{\sin 16.70^\circ}$$

$$\frac{196.2}{0.5298} = \frac{1.129P + 55.388}{0.2874}$$

$$0.598P + 29.345 = 56.388$$

$$0.598P = 27.043; \quad \therefore P = \frac{27.043}{0.598} = \underline{\underline{45.222 \text{ N}}}$$



5. a)

Constant acceleration.

$$v_0 = v_A = 0; \quad x_0 = x_A = 0$$

$$v = v_0 + at = at \quad \text{--- (1)}$$

$$x = x_0 + v_0 t + \frac{1}{2} at^2 = \frac{1}{2} at^2 \quad \text{--- (2)}$$

At point B, $x = x_B = 900\text{m}$ and $t = 30\text{s}$

insert in (2):

$$900\text{m} = \frac{1}{2} a \times (30)^2$$

$$a) \quad a = \frac{2 \times 900}{(30)^2} = \frac{2 \times 900}{900} = 2\text{m/s}^2. \text{ i.e. } \underline{\underline{a = 2\text{m/s}^2}} \text{ ANS.}$$

b) Insert value of a in (1):

$$v = 2 \times 30 = 60\text{m/s}$$

$$\therefore \text{Velocity at B} = \underline{\underline{v_B = 60\text{m/s}}}$$

ANS.

5. b)

* Horizontal Motion

$$x = (V_0)_x t = V_0 \sin 30^\circ \cdot t$$

$$\therefore V_0 t = \frac{x}{\sin 30^\circ} = \frac{5.0 - 0.5}{\sin 30^\circ}$$

$$V_0 t = \frac{4.5}{\sin 30^\circ} = 9.0 \quad \text{--- (1)}$$

Vertical Motion

$$y = y_0 + (V_0)_y t - \frac{1}{2} g t^2$$

$$4\text{m} = 2\text{m} + V_0 \cos 30^\circ \cdot t - \frac{1}{2} \times 9.8 t^2$$

$$4.9 t^2 = -2 + V_0 t \cos 30^\circ \quad \text{--- (2)}$$

Insert (1) in (2):

$$4.9 t^2 = -2 + 9.0 \cos 30^\circ$$

$$4.9 t^2 = -2 + 7.79$$

$$\therefore t^2 = \frac{5.79}{4.9} = 1.182$$

$$\therefore t = 1.087 \text{ sec.}$$

Insert in (1):

$$V_0 \times 1.087 = 9$$

$$\therefore V_0 = \frac{9}{1.087} = \underline{\underline{8.28 \text{ m/s}}}$$

ANS.

-END-

