# GNG 1105 - ENGINEERING MECHANICS

Final Exam | Duration: 3 Hour

December 11, 2013 | Page 1 of 3

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**Closed book Examination. Only non- programmable calculators are allowed. All other electronic devices are not allowed.**

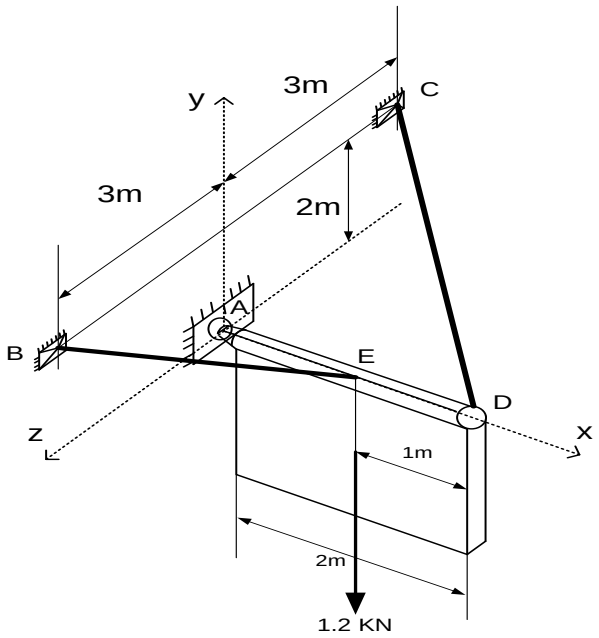
**Solve ONLY four out of the five problems indicated below.**

**Problem1. (25/100)**

A $1m \times 2m$ sign of uniform density weighs 1.2 KN is held in place by a ball-and-socket support at point A and by two cables EB and DC.

a) Write the tensions in cables EB and DC in vector form.

b) Determine the tensions in cables EB and DC.

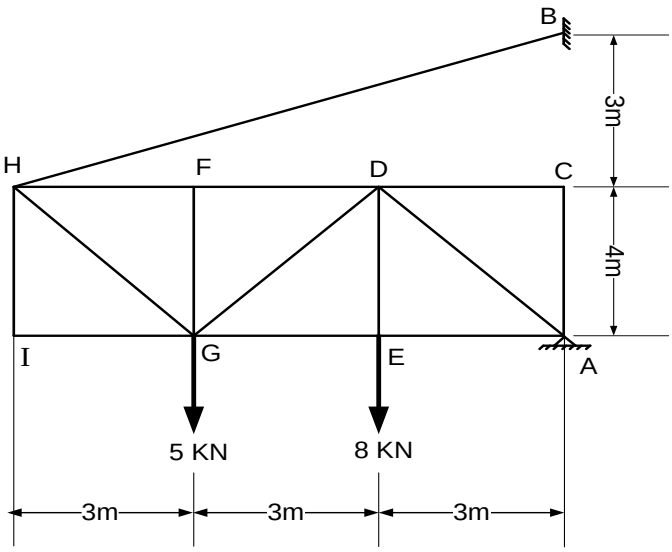


**Problem2. (25/100)**

The truss shown to the right is supported by a pin joint at A and a cable at point B.

a) Determine the reaction at A and the tension in BH.

b) Find the tension or compression in members FD, GD, and GE by the method of sections.

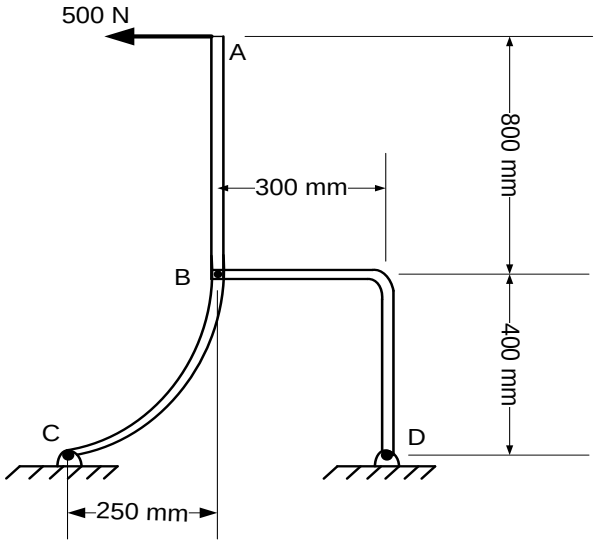



**Problem3. (25/100)**

Lever ABC is attached to a pin joint at C and to a link BD as shown. A force of 500 N is being applied at point A as shown.

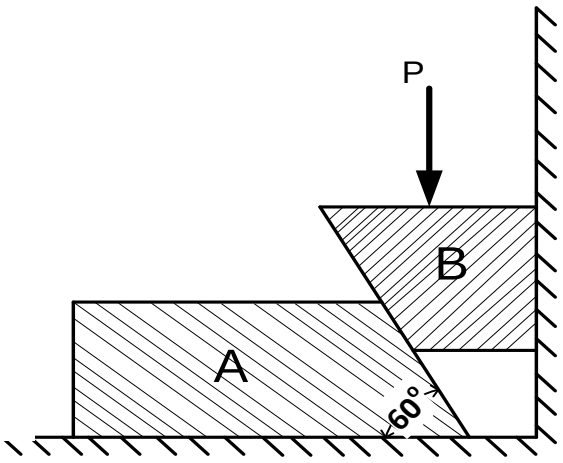
a) Draw the free-body diagrams of lever ABC and link BD, as being disassembled from each other.

b) Find all the forces acting on lever ABC.



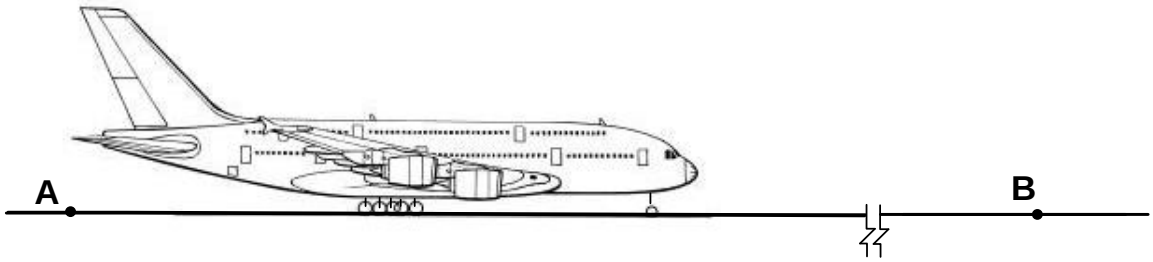

**Problem4. (25/100)**

Block A is of mass 20kg and block B is of mass 5kg. The coefficient of static friction between block B and the vertical wall and block A and the floor is $\mu_{s1}$=0.30, and the coefficient of static friction between the two blocks A&B is $\mu_{s2}$=0.20. Determine the force P necessary for impending motion of block A.

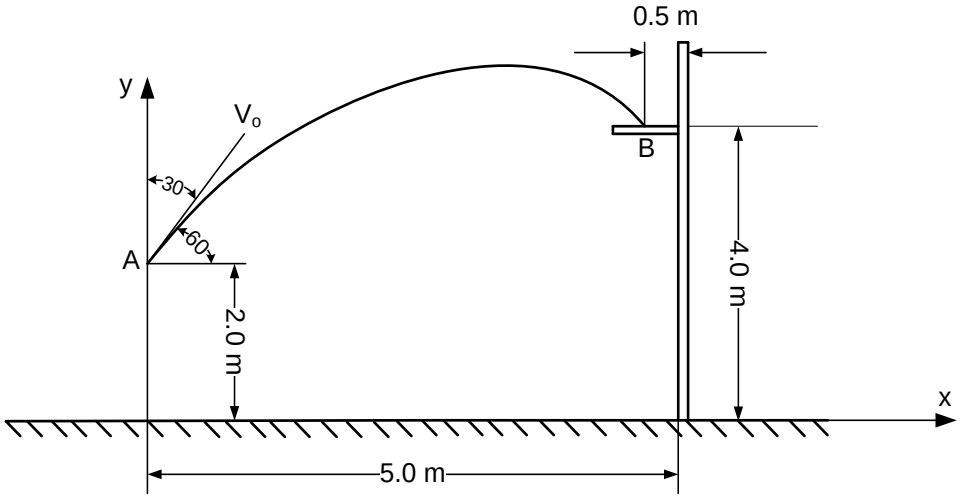


**Problem5. Parts (a) and (b) are independent. (25/100)**

a) An airplane begins to take-off on the runway at point A with zero velocity and a constant acceleration *a*. Knowing that it will take off 30s later at point B and that the distance AB is 900m, determine (a) the acceleration *a*, (b) the take-off velocity $v_B$.




b) A basketball player threw the ball from point A with an initial velocity $v_o$, which makes $60^o$ with the horizontal. It falls through a hoop at B. Determine the initial velocity $v_o$ of the ball (g=9.81 $^{m}/_{s^2}$).




## Useful Equations

$$\boldsymbol{x = x_o + vt}$$
$$\boldsymbol{v = v_o + at}$$
$$\boldsymbol{x = x_o + v_o t + \frac{1}{2}at^2}$$
$$\boldsymbol{v^2 = v_o^2 + 2a(x - x_o)}$$
$$\boldsymbol{\sum \vec{F} = m\vec{a}}$$
$$\boldsymbol{\sum \overrightarrow{F_x} = m\overrightarrow{a_x} \quad , \quad \sum \overrightarrow{F_y} = m\overrightarrow{a_y} \quad , \quad \sum \overrightarrow{F_z} = m\overrightarrow{a_z}}$$

# GNG1105A&E

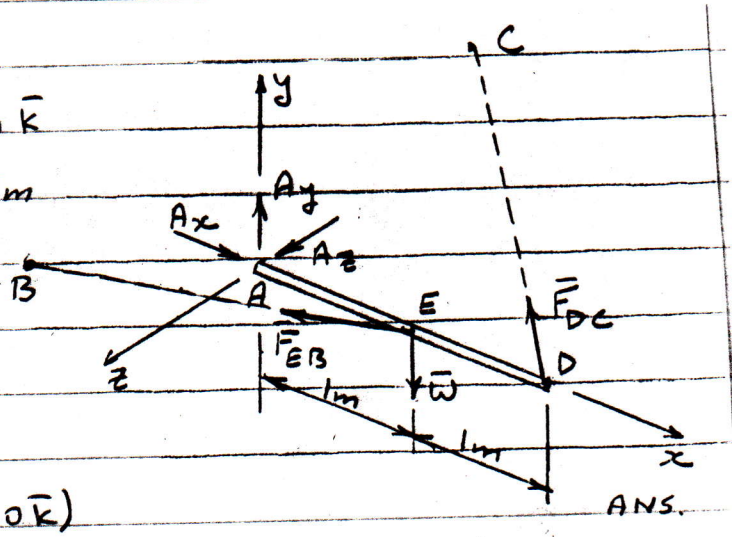
# ENGINEERING MECHANICS

## FINAL EXAM — Dec.11, 2013

## SOLUTIONS

1. a)

FBD – Rod AD




$\bar{EB} = -1.0m\,\bar{i} + 2.0m\,\bar{j} + 3.0m\,\bar{k}$

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

$\bar{DC} = -2.0m\,\bar{i} + 2.0m\,\bar{j} - 3.0m\,\bar{k}$

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

$$\bar{F}_{EB} = F_{EB}\,\lambda_{EB} = F_{EB}\frac{\bar{EB}}{EB}$$

$$= \frac{F_{EB}}{3.74}(-1.0\bar{i} + 2.0\bar{j} + 3.0\bar{k})$$

ANS.

$$\bar{F}_{DC} = F_{DC}\,\bar{\lambda}_{DC} = F_{DC}\frac{\bar{DC}}{DC}$$

$$= \frac{F_{DC}}{4.12}(-2.0\bar{i} + 2.0\bar{j} - 3.0\bar{k})$$

ANS.

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

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

$\therefore \Sigma \bar{M}_A = 1.0\bar{i} \times \frac{F_{EB}}{3.74}(-1.0\bar{i} + 2.0\bar{j} + 3.0\bar{k})$ (cyclic: $\bar{k}\ \bar{j}\ \bar{i}$)

$+ 2.0\bar{i} \times \frac{F_{DC}}{4.12}(-2.0\bar{i} + 2.0\bar{j} - 3.0\bar{k}) + 1.0\bar{i}(-1.2kN\,\bar{j}) = 0$

Hence, $\Sigma M_A = 0.53F_{EB}\,\bar{k} - 0.80F_{EB}\,\bar{j} + 0.97F_{DC}\,\bar{k} + 1.46F_{DC}\,\bar{j} - 1.2\bar{k} = 0$

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

$\bar{j}$: $-0.80F_{EB} + 1.46F_{DC} = 0$ ——— (1)

$\bar{k}$: $0.53F_{EB} + 0.97F_{DC} - 1.2 = 0$ ——— (2)

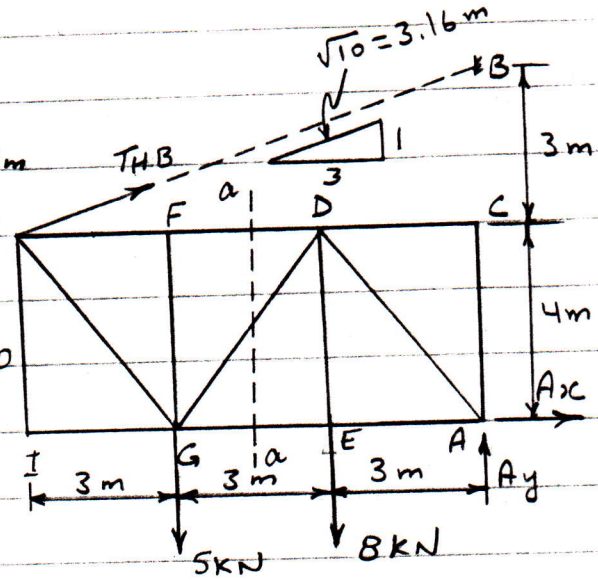
Multiply (1) by 0.53 and (2) by 0.8 and add

$2.92F_{DC} - 1.81 = 0$; $\therefore F_{DC} = \underline{0.62\ kN}$ ANS.

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

2. a)

FBD – Entire truss




$+\circlearrowleft \Sigma M_A = 0$

$5KN \times 6m + 8KN \times 3m - T_{HB} \times \frac{3}{3.16} \times 4m - T_{HB} \times \frac{1}{3.16} \times 9m = 0$

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

$6.65 T_{HB} = 54.00$

$\therefore T_{HB} = \underline{8.12\ KN}$

$\pm \Sigma F_x = 0$

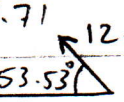
$A_x + 8.12 \times \frac{3}{3.16} = 0, \quad \therefore A_x = \underline{-7.71\ kN}$

$+\uparrow \Sigma F_y = 0$

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

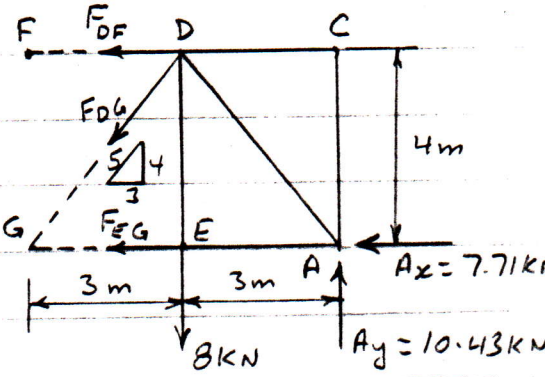
$A_y = 5 + 8 - 2.57 = \underline{10.43\ KN}$

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




$\therefore A = \underline{12.97\ kN}$ ANS.

b) FBD – Section right of aa.




$+\circlearrowleft \Sigma M_D = 0$

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

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

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

$+\circlearrowleft \Sigma M_G = 0$

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

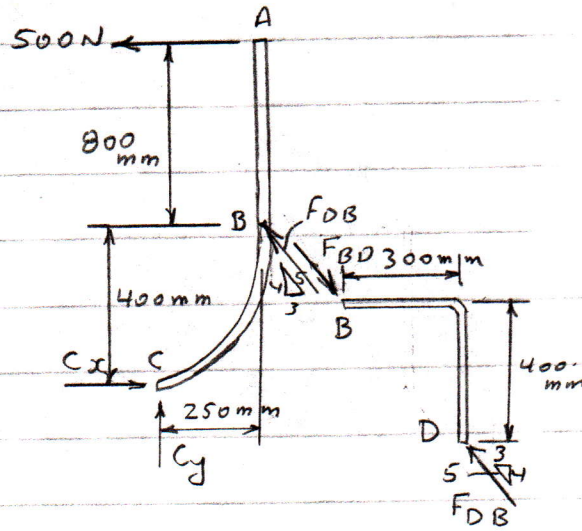
$+\uparrow \Sigma F_y = 0; \quad -F_{DG} \times \frac{4}{5} - 8\ kN + 10.43\ kN = 0; \quad \frac{4}{5} F_{DG} = 2.43\ kN$

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

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

3.

a) See Diagram




b) Link BD is a 2-Force member.

FBD- Lever ABC

$+\circlearrowleft \Sigma M_C = 0$

$F_{DB} \times \frac{3}{5} \times 400mm + F_{DB} \times \frac{4}{5} \times 250mm + 500N \times 1200mm = 0$

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

$440 F_{DB} = -600000$

$\therefore F_{DB} = \underline{\underline{-1363.64 N}} \searrow$ ANS.

$\xrightarrow{+} \Sigma F_x = 0$

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

$\therefore C_x = -318.18 N$

$+\uparrow \Sigma F_y = 0$

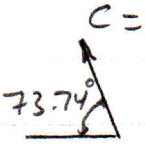
$C_y - 1363.64 \times \frac{4}{5} = 0$

$\therefore C_y = 1090.91 N$

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

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

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



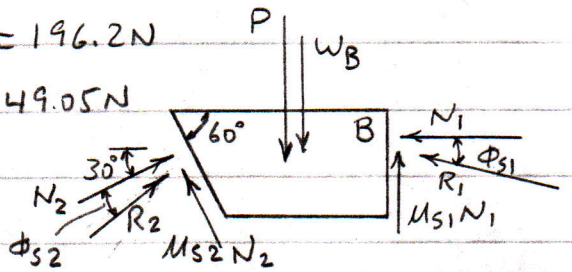

ANS.

4.

FBD - Block A & Block B

Weight of block A = $W_A = 20 \times 9.81 = 196.2\,N$

Weight of block B = $W_B = 5 \times 9.81 = 49.05\,N$

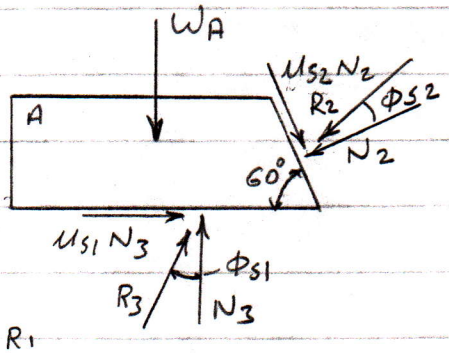



$\Phi_{S1} = \tan^{-1}\mu_{S1}$

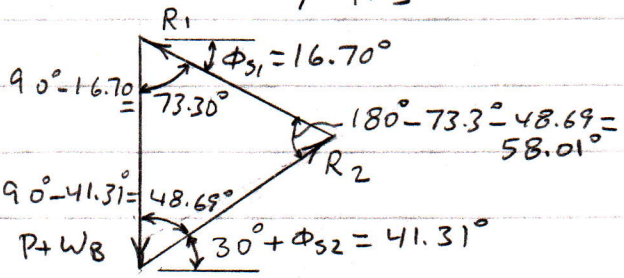
$\Phi_{S1} = \tan^{-1} 0.3 = \underline{16.70°}$

$\Phi_{S2} = \tan^{-1}\mu_{S2}$

$\Phi_{S2} = \tan^{-1} 0.2 = \underline{11.31°}$



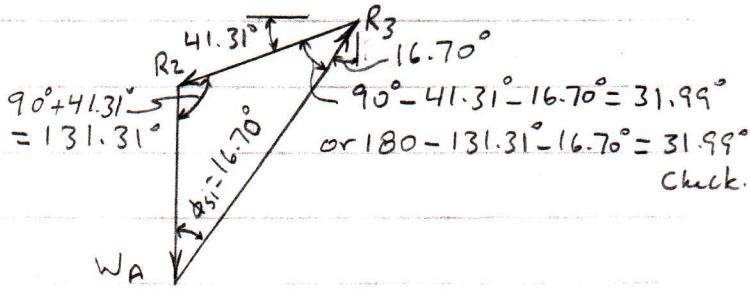

Force triangle: Block B




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

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

Force triangle: Block A




$$\frac{W_A}{\sin 31.99°} = \frac{R_2}{\sin 16.70°}$$

Insert $R_2$ from eq. (1):

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

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

$$0.598P + 29.345 = 56.388$$

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

5. a)

Constant acceleration.

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

$v = v_0 + at = at$ ——— (1)

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

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

Insert in (2):

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

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

b) Insert value of a in (1):

$v = 2 \times 30 = 60\,m/s$.

∴ Velocity at B = $\underline{\underline{v_B = 60\,m/s}}$ ANS.

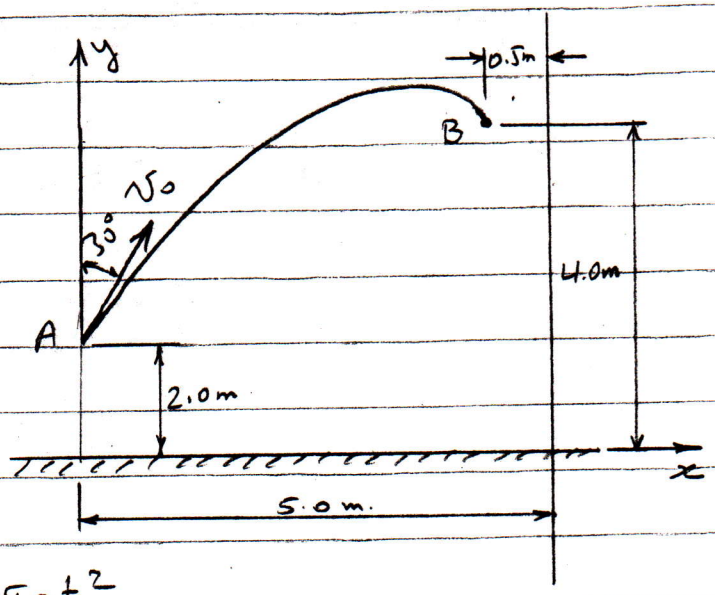
5. b)

*- Horizontal Motion

$x = (v_0)_x t = v_0 \sin 30^\circ . t$

$\therefore v_0 t = \frac{x}{\sin 30^\circ} = \frac{5.0 - 0.5}{\sin 30^\circ}$

$v_0 t = \frac{4.5}{\sin 30^\circ} = 9.0$ — (1)




Vertical Motion

$y = y_0 + (v_0)_y t - \frac{1}{2} g t^2$

$4m = 2m + v_0 \cos 30^\circ . t - \frac{1}{2} \times 9.80 t^2$

$4.9 t^2 = -2 + v_0 t \cos 30^\circ$ — (2)

Insert (1) in (2):

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

$4.9 t^2 = -2 + 7.79$

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

$\therefore t = 1.087$ 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-