

## GNG 1105 - ENGINEERING MECHANICS

Final Exam

Duration: 3 Hour

December 11, 2013

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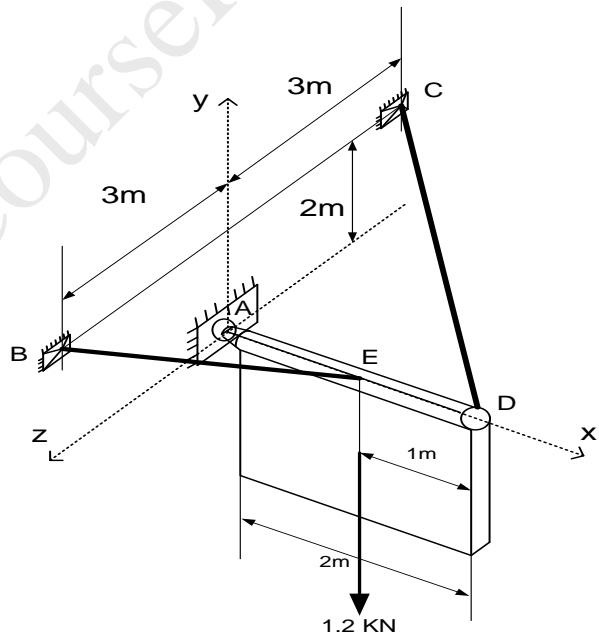
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**Closed book Examination. Only non- programmable calculators are allowed.  
All other electronic devices are not allowed.**

**Solve ONLY four out of the five problems indicated below.**  
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### **Problem1. (25/100)**

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

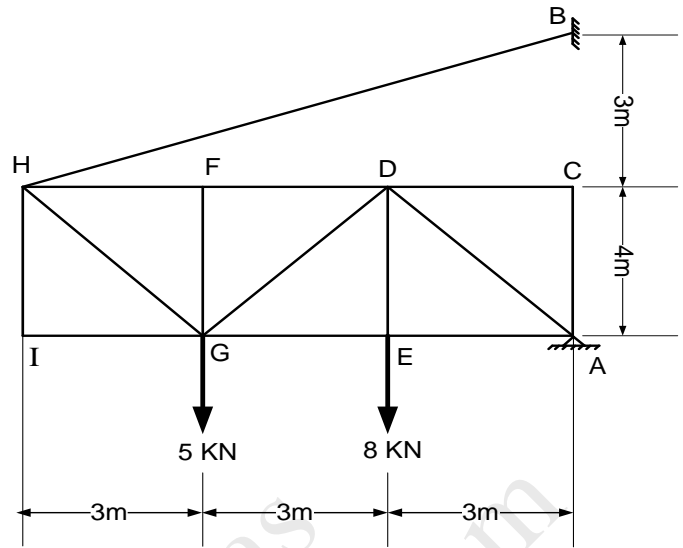
- Write the tensions in cables EB and DC in vector form.
- Determine the tensions in cables EB and DC.



**Problem2. (25/100)**

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

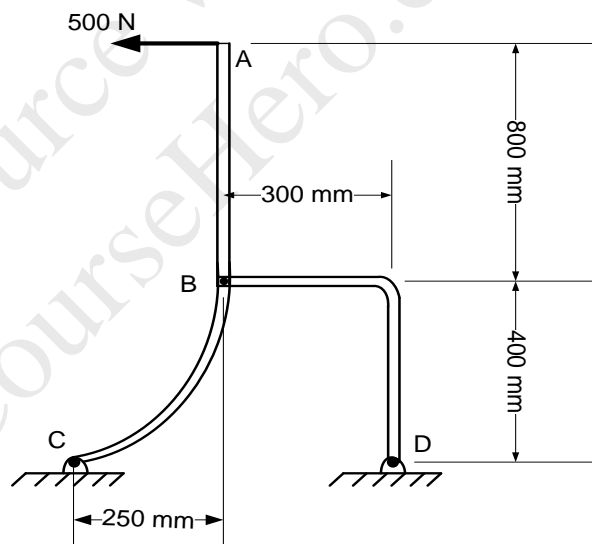
- Determine the reaction at A and the tension in BH.
- Find the tension or compression in members FD, GD, and GE by the method of sections.



**Problem3. (25/100)**

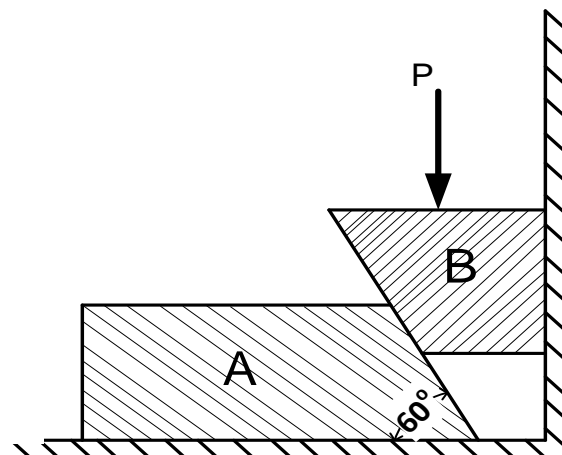
Lever ABC is attached to a pin joint at C and to a link BD as shown. A force of 500 N is being applied at point A as shown.

- Draw the free-body diagrams of lever ABC and link BD, as being disassembled from each other.
- Find all the forces acting on lever ABC.



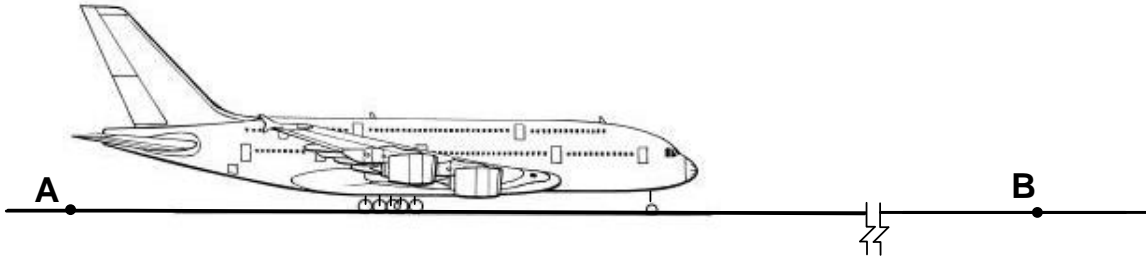
**Problem4. (25/100)**

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.

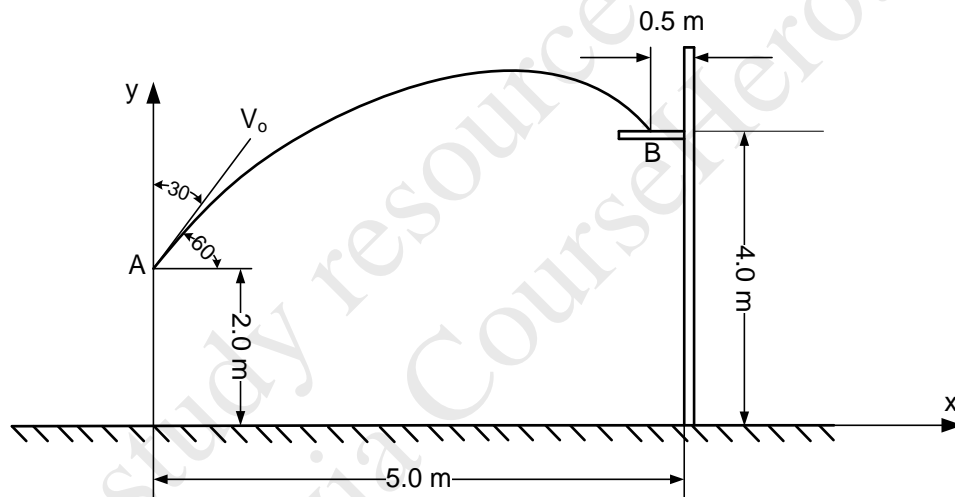


**Problem 5. Parts (a) and (b) are independent. (25/100)**

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  $60^\circ$  with the horizontal. It falls through a hoop at B. Determine the initial velocity  $v_o$  of the ball ( $g=9.81 \text{ m/s}^2$ ).



**Useful Equations**

$$x = x_o + vt$$

$$v = v_o + at$$

$$x = x_o + v_o t + \frac{1}{2} at^2$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

$$\sum \vec{F} = m\vec{a}$$

$$\sum \vec{F}_x = m\vec{a}_x \quad , \quad \sum \vec{F}_y = m\vec{a}_y \quad , \quad \sum \vec{F}_z = m\vec{a}_z$$

GNUG1105A&E  
ENGINEERING MECHANICS  
FINAL EXAM  
SOLUTIONS

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1. a)

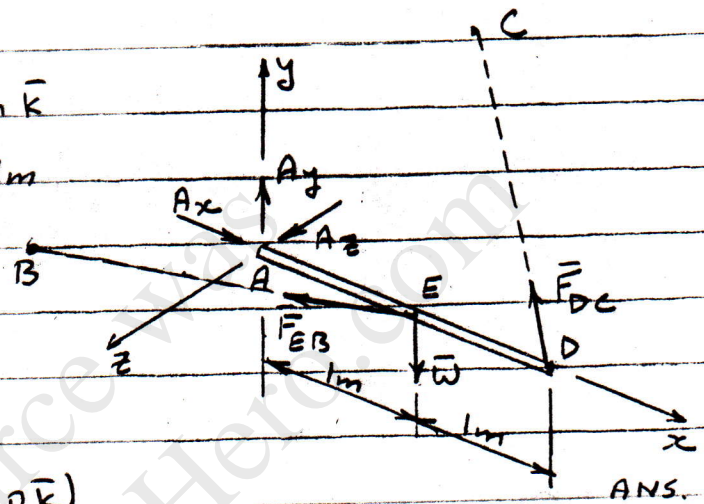
FBD - Rod AD

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

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

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

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



$$\vec{F}_{EB} = F_{EB} \lambda_{EB} = F_{EB} \frac{\vec{EB}}{EB}$$

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

$$\vec{F}_{DC} = F_{DC} \lambda_{DC} = F_{DC} \frac{\vec{DC}}{DC}$$

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

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

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

$$\therefore \sum \vec{M}_A = 1.0\vec{i} \times \frac{F_{EB}}{3.74} (-1.0\vec{i} + 2.0\vec{j} + 3.0\vec{k})$$

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

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

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

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

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

$$\uparrow \sum M_A = 0$$

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

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

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

$$6.65 T_{HB} = 54.00$$

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

$$\rightarrow \sum F_x = 0$$

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

$$\uparrow \sum F_y = 0$$

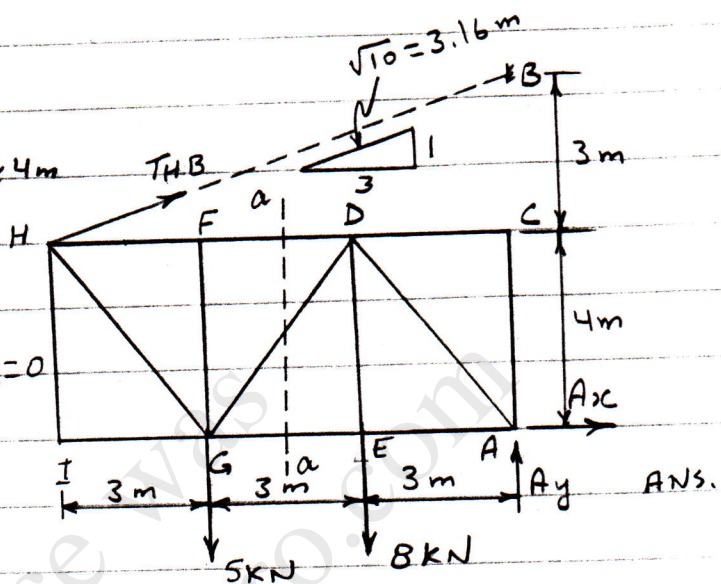
$$A_y + 8.12 \times \frac{1}{3.16} - 5 - 8 = 0$$

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

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

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

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



b) FBD - section right of aa.

$$\uparrow \sum M_D = 0$$

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

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

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

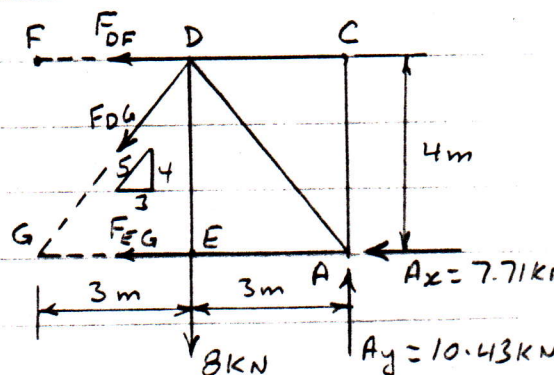
$$\uparrow \sum M_G = 0$$

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

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

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

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



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.

$$\rightarrow \sum F_x = 0$$

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

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

$$\uparrow \sum F_y = 0$$

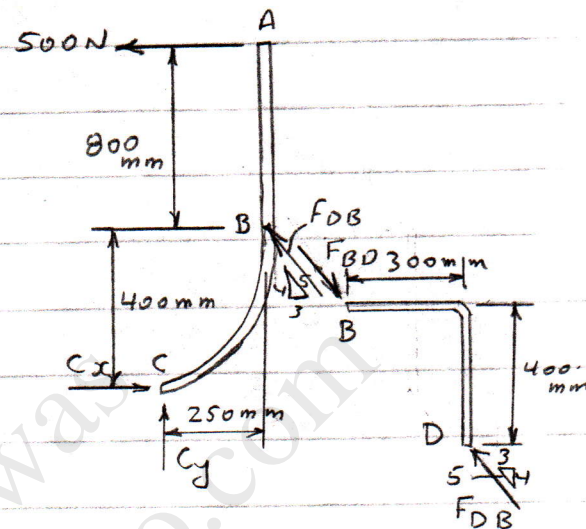
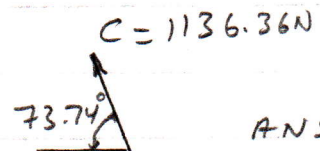
$$C_y - 1363.64 \times \frac{4}{5} = 0$$

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

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

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

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



4.

FBD - Block A & Block B

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

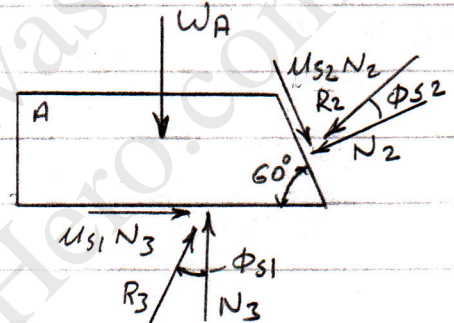
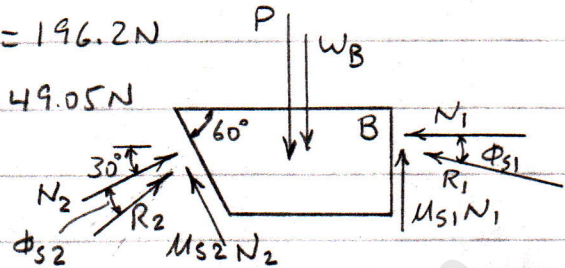
$$\text{Weight of block B} = W_B = 5 \times 9.81 = 49.05 \text{ N}$$

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

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

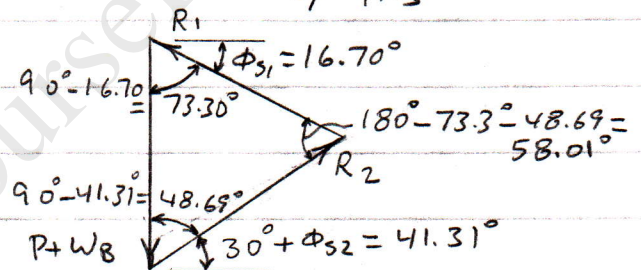
$$\phi_{s2} = \tan^{-1} \mu_{s2}$$

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

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

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

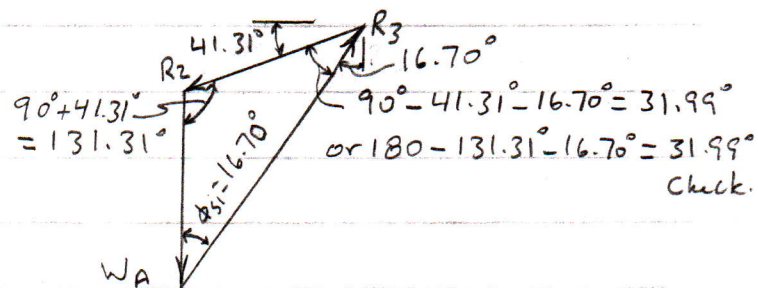
Insert  $R_2$  from eq. (1):

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

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

$$0.598P + 29.345 = 56.388$$

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



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):

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

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

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-

