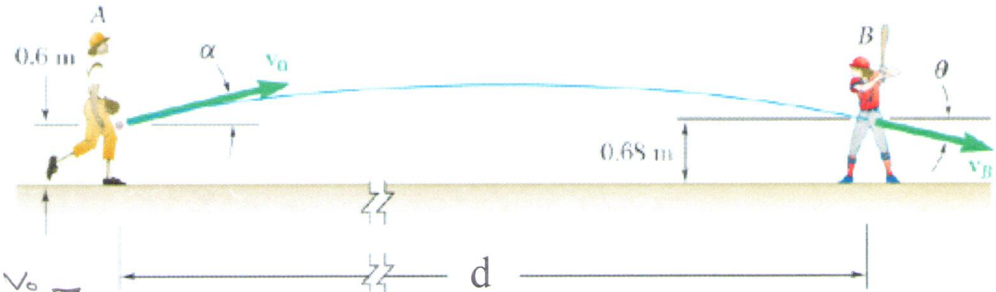
Alabama A&M University

Mechanical Engineering Department

ME 206 – Dynamics: Fall 2016 – Test #1

Student's name KEY

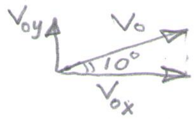
1. The pitcher in a softball game throws a ball with an initial velocity v_o of 20 m/s at an angle α with the horizontal. If the height of the ball at Point B is 0.68 m and the angle α is 10 °, determine:
   (a) The distance d
   (b) The angle θ that the velocity of the ball at Point B forms with the horizontal.



$V_o = 20$ m/s

$V_{ox} = 20 \cos 10°$

$V_{oy} = 20 \sin 10°$



a) Vertical Motion (Uniformly accelerated motion: $a_y = -g$)

$$y = y_o + V_{oy} t + \frac{1}{2} a_y t^2$$

$$0.68 = 0.6 + 20(\sin 10) \cdot t - (0.5 \times 9.81) t^2$$

$$0.68 = 0.6 + 3.473 t - 4.905 t^2$$ rearrang:

$$4.905 t^2 - 3.473 t + 0.08 = 0$$ Solve for t:

$$t = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} = \frac{+3.473 \pm \sqrt{(3.473)^2 - 4(4.905)(0.08)}}{2(4.905)}$$

$= 0.6842$ Sec. OR $= 0.0238$ Sec.

Horizontal Motion, $x = x_o + V_{ox} t$

For $t = 0.6842$ Sec: $x = 0 + 20(\cos 10°)(0.6842) = \boxed{13.476 \text{ m}}$

For $t = 0.0238$ Sec: $x = 0 + 20(\cos 10°)(0.0238) = 0.4688$ m ⇒ Rejected not practical

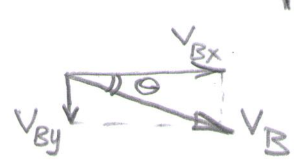
Hence: $\boxed{x = d = 13.476 \text{ m}}$

b) at B:

$V_{xB} = V_{ox} = 20 \cos 10 = 19.696$ m/sec. →

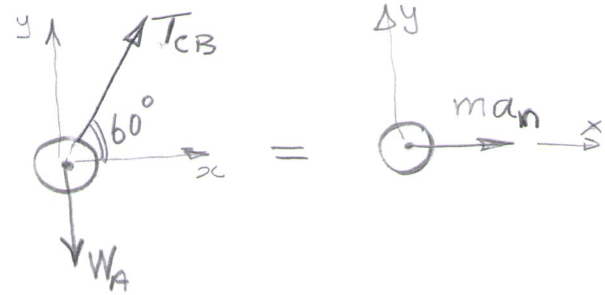
$V_{yB} = V_{oy} - gt = 20 \sin 10 - 9.81(0.6842) = -3.239$ m/sec. ↓

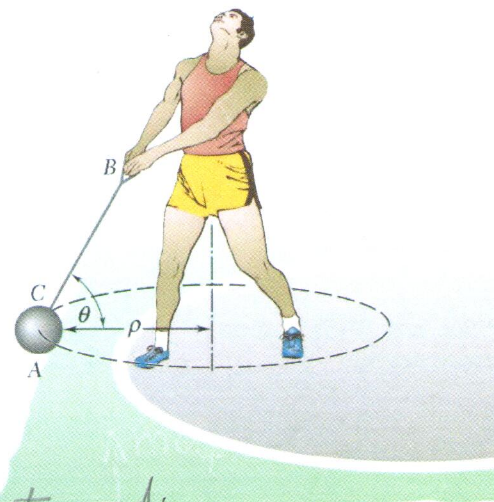
$$\theta = \tan^{-1} \frac{V_{yB}}{V_{xB}} = \tan^{-1} \frac{-3.239}{19.696} = \boxed{-9.339°}$$



2. During a hammer thrower's practice swings, the 7.1-kg head A of the hammer revolves at a constant speed v in a horizontal circle as shown. If $\rho = 0.93$ m and $\theta = 60^\circ$, determine (a) the tension in wire BC, (b) the speed of the hammer's head.

FBD:





Since the mass A is rotating at a constant speed:

$$a_n = \frac{V_A^2}{\rho}$$

$$a_t = 0$$

a) $+\uparrow \sum F_y = m a_y \; (= 0)$

$$T_{CB} \sin 60 - W_A = 0$$

$$T_{CB} \sin 60 = W_A$$

$$T_{CB} = \frac{W_A}{\sin 60} = \frac{M_A g}{\sin 60} = \frac{7.1 \times 9.81}{\sin 60} = \boxed{80.426\ N}$$

b) $\overset{+}{\rightarrow} \sum F_x = m_A a_x$

$$T_{CB} \cos 60 = 7.1 \left(\frac{V_A^2}{\rho}\right)$$

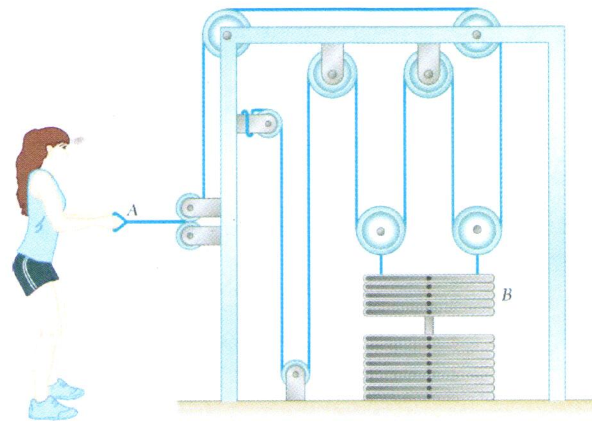
$$80.426 (\cos 60) = 7.1 \times \frac{V_A^2}{0.93}$$

$$V_A^2 = \frac{(80.426)(\cos 60)(0.93)}{7.1} = 5.2673$$

$$V_A = \sqrt{5.2673} = 2.295 \quad m/sec.$$

$$\therefore \boxed{V_A = 2.3 \quad m/sec.}$$

3. An athlete pulls handle A to the left with a constant force of P = 100 N. Knowing that after the handle A has been pulled 0.30 m its velocity is 3 m/s, determine the mass of the weight stack B.



Given: $P = 100\ N$

$x_A = 0.30\ m$

$V_A = 3\ m/s$

Kinematic Relation:

$$\Delta X_A = 4(\Delta Y_B)$$
$$V_A = 4 V_B$$
$$a_A = 4 a_B \qquad (1)$$

Uniform Acceleration of Handle A:

$$V_A^2 = (V_A)_0^2 + 2 a_A (X_A - X_{A_0})$$
$$3^2 = 0^2 + 2 a_A (0.3 - 0)$$
$$9 = 0.6 a_A$$
$$a_A = \frac{9}{0.6} = \boxed{15\ m/s^2} \leftarrow$$

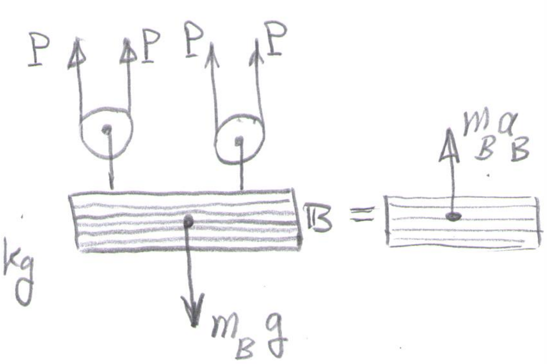
From equation (1): $a_B = \frac{a_A}{4} = \frac{15}{4} = \boxed{3.75\ m/s} \uparrow$

From: FBD:

$$\Sigma F_y = m_B a_B$$
$$4P - m_B g = m_B a_B$$
$$4P = m_B (g + a_B)$$
$$m_B = \frac{4P}{g + a_B} = \frac{4 \times 100}{9.81 + 3.75} = 29.5\ kg$$

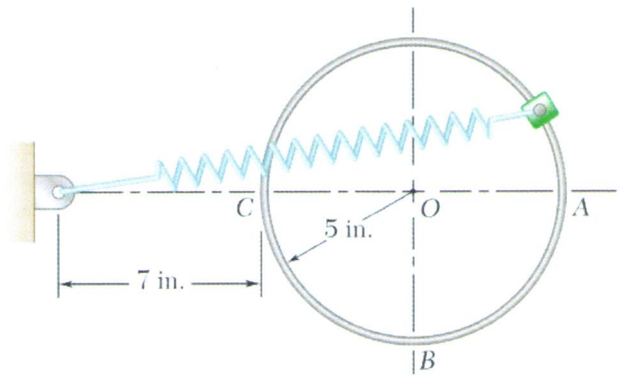
$$\therefore \boxed{m_B = 29.5\ kg}$$

Free Body Diagram:

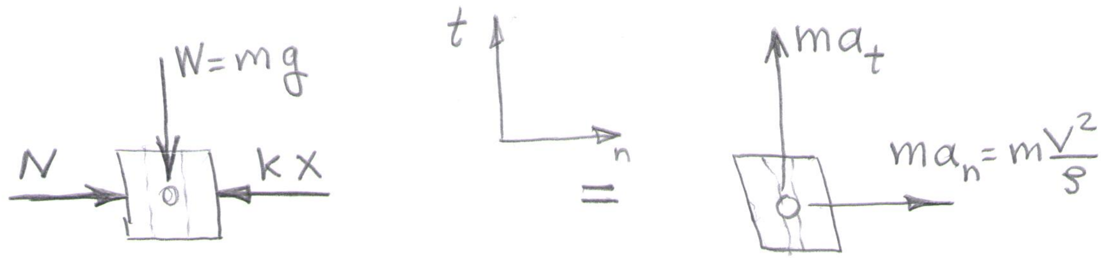


Extra Credit:

A collar of mass m is attached to a spring and slides without friction along a circular rod in a vertical plane. The spring has an undeformed length of 5 in. and a constant k. Knowing that the collar has a speed v at Point C, draw the FBD and KD of the collar at this point.



at point C;



where: $x = \frac{2}{12}$ ft

$\rho = \frac{5}{12}$ ft