CLASS:	PHY_____
STUDENT #:	______________
NAME:	______________________

UNIVERSITY OF OTTAWA
Principles of Physics
PHY1321/1331 FALL 2016
Dr. A. Czajkowski

Assignment 8:
Kinematics and Dynamics

Assigned: Nov 4: *Due: Nov 11 6 PM*

1. A dive bomber has a velocity of 280m/s at an angle θ below the horizontal. When the altitude of the aircraft is 2.15 km, it releases a bomb, which subsequently hits a target on the ground. The magnitude of the displacement from the point of release of the bomb to the target is 3.25 km. Find the angle θ.

When the bomb has fallen a vertical distance 2.15 km, it has traveled a horizontal distance x_f given by

$$x_f = \sqrt{(3.25\text{ km})^2 - (2.15\text{ km})^2} = 2.437\text{ km}$$

$$y_f = x_f \tan\theta - \frac{g x_f^2}{2 v_i^2 \cos^2\theta_i}$$

$$-2\,150\text{ m} = (2\,437\text{ m})\tan\theta_i - \frac{(9.8\text{ m/s}^2)(2\,437\text{ m})^2}{2(280\text{ m/s})^2\cos^2\theta_i}$$

$$\therefore -2\,150\text{ m} = (2\,437\text{ m})\tan\theta_i - (371.19\text{ m})(1 + \tan^2\theta_i)$$

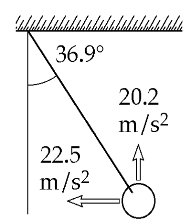
$$\therefore \tan^2\theta - 6.565\tan\theta_i - 4.792 = 0$$

$$\therefore \tan\theta_i = \frac{1}{2}\left(6.565 \pm \sqrt{(6.565)^2 - 4(1)(-4.792)}\right) = 3.283 \pm 3.945.$$

Select the negative solution, since θ_i is below the horizontal.

$$\therefore \tan\theta_i = -0.662\,,\quad \boxed{\theta_i = -33.5^\circ}$$

2 A ball swings in a vertical circle at the end of a rope 1.50 m long. When the ball is 36.9° past the lowest point on its way up, its total acceleration is $\left(-22.5\hat{\mathbf{i}} + 20.2\hat{\mathbf{j}}\right)\text{m/s}^2$. At that instant, (a) sketch a vector diagram showing the components of its acceleration, (b) determine the magnitude of its radial acceleration, and (c) determine the magnitude and direction of the velocity of the ball. (with respect to horizontal)



(a) See figure to the right.

(b) The components of the 20.2 and the 22.5 m/s^2 along the rope together constitute the centripetal acceleration:

$$a_c = (22.5\text{ m/s}^2)\cos(90.0^\circ - 36.9^\circ) + (20.2\text{ m/s}^2)\cos 36.9^\circ = \boxed{29.7\text{ m/s}^2}$$

(c) $a_c = \dfrac{v^2}{r}$ so $v = \sqrt{a_c r} = \sqrt{29.7\text{ m/s}^2\,(1.50\text{ m})} = 6.67\text{ m/s}$ tangent to circle

$\mathbf{v} = \boxed{6.67\text{ m/s at } 36.9^\circ \text{ above the horizontal}}$

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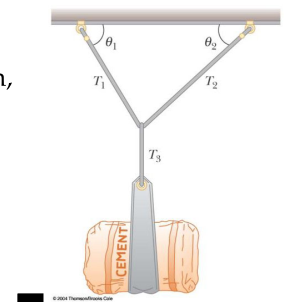
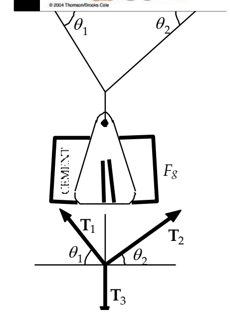
3A bag of cement of weight of F_g hangs from three wires as shown. Two of the wires make angles θ_1 and θ_2 with the horizontal. If the system is in equilibrium, show that the tension in the left-hand wire is $T_1 = F_g \cos\theta_2/\sin(\theta_1+\theta_2)$



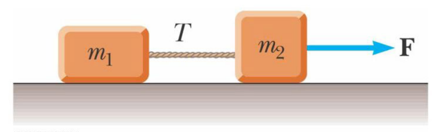


$$T_3 = F_g \quad (1)$$
$$T_1 \sin\theta_1 + T_2 \sin\theta_2 = F_g \quad (2)$$
$$T_1 \cos\theta_1 = T_2 \cos\theta_2 \quad (3)$$

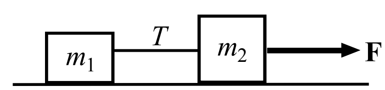
Eliminate T_2 and solve for T_1

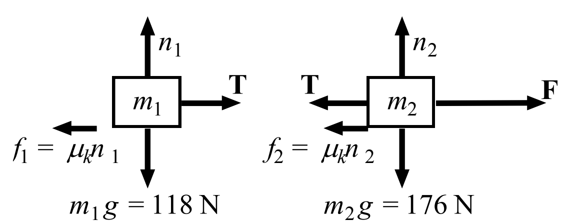
$$T_1 = \frac{F_g \cos\theta_2}{(\sin\theta_1 \cos\theta_2 + \cos\theta_1 \sin\theta_2)} = \frac{F_g \cos\theta_2}{\sin(\theta_1+\theta_2)}$$

4 Two blocks connected by a rope of negligible mass are being dragged by a horizontal force **F** (Fig. P5.45). Suppose that F = 68.0 N, m_1 = 12.0 kg, m_2 = 18.0 kg, and the coefficient of kinetic friction between each block and the surface is 0.100. (a) Draw a free-body diagram for each block. (b) Determine the tension T and the magnitude of the acceleration of the system.



See Figure to the right





$$68.0 - T - \mu m_2 g = m_2 a \quad \text{(Block \#2)}$$
$$T - \mu m_1 g = m_1 a \quad \text{(Block \#1)}$$

Adding,

$$68.0 - \mu(m_1+m_2)g = (m_1+m_2)a$$
$$a = \frac{68.0}{(m_1+m_2)} - \mu g = \boxed{1.29\ \text{m/s}^2}$$
$$T = m_1 a + \mu m_1 g = \boxed{27.2\ \text{N}}$$

5 A crate of weight $\mathbf{F}_g$ is pushed by a force **P** on a horizontal floor. (a) If the coefficient of static friction is μ_s and **P** is directed at angle θ below the horizontal, show that the minimum value of P that will move the crate is given by

$$P = \frac{\mu_s F_g \sec\theta}{1 - \mu_s \tan\theta}$$

(b) Find the minimum value of P that can produce motion when μ_s = 0.400, F_g = 100 N, and θ = 0°, 15.0°, 30.0°, 45.0°, and 60.0°.

The crate is in equilibrium, just before it starts to move.
Let the normal force acting on it be n and the friction force f_s.

Resolving vertically: $n = F_g + P\sin\theta$

Resolving Horizontally: $P\cos\theta = f_s$

But, $f_s \le \mu_s n$

i.e., $P\cos\theta \le \mu_s\left(F_g + P\sin\theta\right)$

or $P\left(\cos\theta - \mu_s \sin\theta\right) \le \mu_s F_g$.

Divide by $\cos\theta$: $P\left(1-\mu_s \tan\theta\right) \le \mu_s F_g \sec\theta$.

Then $\boxed{P_{\text{minimum}} = \dfrac{\mu_s F_g \sec\theta}{1-\mu_s \tan\theta}}$.

(b) $P = \dfrac{0.400(100\text{ N})\sec\theta}{1-0.400\tan\theta}$

$\theta(\text{deg})$	0.00	15.0	30.0	45.0	60.0
$P(N)$	40.0	46.4	60.1	94.3	260

If the angle were $68.2°$ or more, the expression for P would go to infinity and motion would become impossible.

$v \le \boxed{14.3\text{ m/s}}$