PHYS 101 Midterm Examination #1 (version A)

June 10, 2011

Time: 50 minutes

Last Name : Key

First Name : ____________________

Student No. : ____________________

Computing ID : ____________________

Tutorial Section : ____________________

	score	*Maximum*
Multiple Choice		*7*
Written # 1		*5*
Written # 2		*5*
Written # 3		*5*
Total		*22*

Part I (Multiple choice questions. 1 mark each.)

B

1. A block of mass m rests on the floor of an elevator that is moving upward at a constant speed. Compare the magnitude of the normal force (N) and the gravitational force on the block.

(A) $N > mg$
(B) $N = mg$
(C) $N < mg$ (but not zero)
(D) $N = 0$

Constant $\vec{v}$: $\vec{a} = 0$.

$\Sigma \vec{F} = 0$.

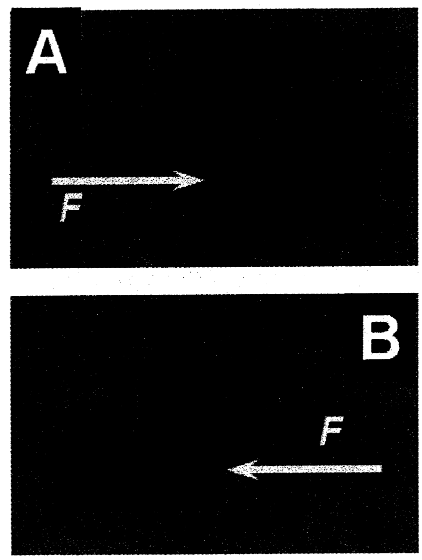
A

2. If you push with force F on either the heavy box (m_1) or the light box (m_2), in which of the two cases is the contact force between the two boxes larger? Ignore friction.

(A) case A
(B) case B
(C) same in both cases

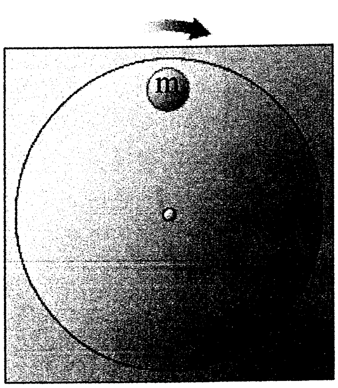
$m_1 \frac{F}{m_1 + m_2}$ $m_2 \frac{F}{m_1 + m_2}$

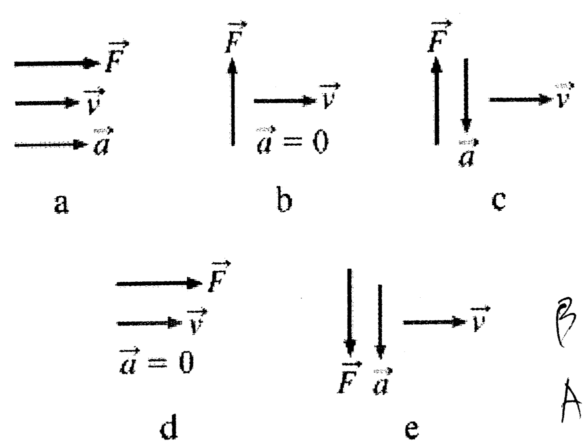
$m_1 > m_2$



E

3. Object m is in a uniform circular motion as shown in the diagram. Which of the following sets of vectors best describes its velocity $\vec{v}$, acceleration $\vec{a}$, and the net force acting on it ($\vec{F}$)?





B A E.   E B D B

(A) a; (B) b; (C) c; (D) d; (E) e.

E

4. Does the centripetal force acting on an object do work on the object?
   A) Yes, since a force acts and the object moves, and work is force times distance.
   B) Yes, since it takes energy to turn an object.
   C) No, because the object has constant speed.
   D) No, because the object's displacement is zero.
   (E) No, because the force and the displacement of the object are perpendicular.

B

5. A baseball of mass 0.15 kg moving at 20.0 m/s strikes the glove of a catcher. The glove recoils a distance of 5.0 cm. The magnitude of the average force applied by the ball on the glove is
   A) 667 N
   (B) 600 N
   C) 60 N
   D) 3 N
   E) 0.15 N

$$F \cdot d = \frac{1}{2} m v^2$$

$$F = \frac{m v^2}{2d} = \frac{0.15 \times 20^2}{2 \times 0.05} = 600\ N$$

D

6. A 0.15-kg baseball is dropped from rest. It has a speed of 1.4 m/s just before it hits the ground. It rebounds with a speed of 1.0 m/s. The ball is in contact with the ground for 0.0015 s. What is the average force exerted by the ground on the ball during that time?
   A) 40 N
   B) 100 N
   C) 220 N
   (D) 240 N
   E) 140 N

$$F \Delta t = P_f - P_i = m(v_f - v_i)$$

$$F = \frac{0.15[1.0 - (-1.4)]}{0.0015}$$

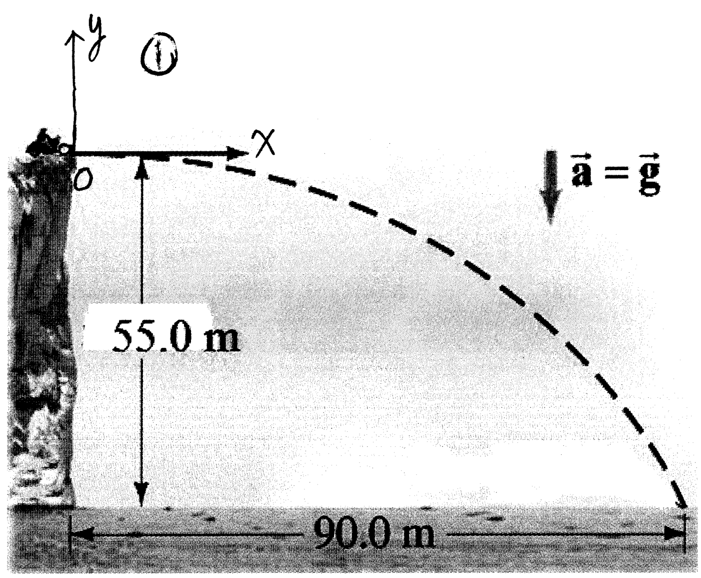
B

7. A car and a minivan collide and stick together. Consider the total momentum and the total kinetic energy of the two vehicles before and after the collision. Which of the following statements is true?
   (A) Both the total momentum and total kinetic energy are conserved.
   (B) The total momentum is conserved but the total kinetic energy is not conserved.
   (C) Neither the total momentum nor the total kinetic energy is conserved.
   (D) The total kinetic energy is conserved but the total momentum is not conserved.
   (E) The change in total momentum equals the change in total kinetic energy.

Part II (Full solution questions, 5 marks each. **SHOW ALL WORK FOR FULL MARKS!**)

8. A movie stunt driver on a motorcycle speeds horizontally off a 55.0-m-high cliff. How fast must the motorcycle leave the cliff top to land on level ground below, 90.0 m from the base of the cliff where the cameras are? Ignore air resistance.

0.5
$$\begin{cases} x_0 = 0, \quad y_0 = 0, \\ v_{0x} = \text{unknown}, \quad v_{0y} = 0, \\ a_x = 0, \quad a_y = -g. \end{cases}$$



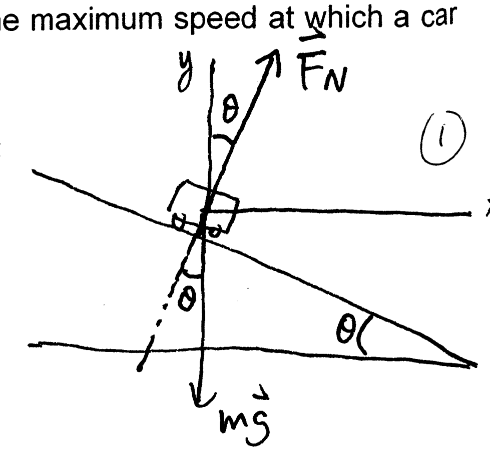
②
$$\begin{cases} x = x_0 + v_{0x} t \\ y = y_0 + v_{0y} t - \frac{1}{2} g t^2 \end{cases}$$

$$\begin{cases} \text{at time } t: \quad x = 90.0\,m, \\ \qquad y = -55.0\,m. \end{cases}$$

①
$$\begin{cases} 90 = v_{0x} t \\ -55 = -\frac{1}{2} g t^2 \end{cases} \longrightarrow \quad t = \sqrt{\frac{2 \times 55}{9.8}} = 3.35\,s.$$

0.5 $\quad v_{0x} = \frac{90}{t} = 26.9\ m/s.$

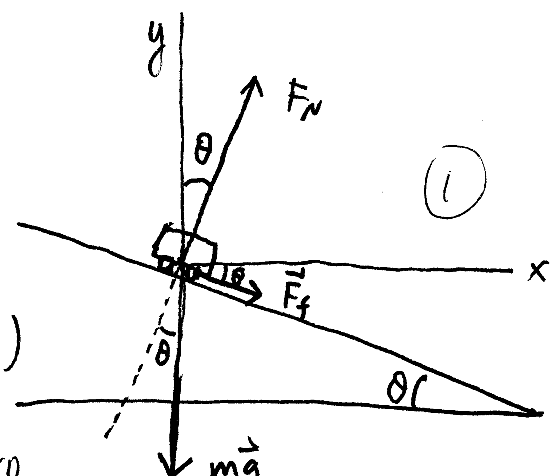
9. (**Show the free-body-diagram for full marks**). At the entrance of a free way, a curve of radius 150m is banked for a design speed of 60 km/h.
(a) Determine the banking angle (so that no friction is reuired if the speed is 60km/h).
(b) If the coefficient of static friction is 0.10, what is the maximum speed at which a car can safely handle the curve?



a). $\vec{F} = m\vec{a}$ $\qquad v = 60\ km/h = 16.7\ m/s$

① $\begin{cases} F_N \sin\theta = m\dfrac{v^2}{R} \\ F_N \cos\theta - mg = 0 \end{cases}$

0.5 $\begin{cases} \tan\theta = \dfrac{v^2}{Rg} = \dfrac{16.7^2}{150 \times 9.8} = 0.189 \\ \theta = 10.7^\circ . \end{cases}$



b). ① $\begin{cases} F_N \sin\theta + F_f \cos\theta = m\dfrac{v^2}{R} \\ F_N \cos\theta - F_f \sin\theta - mg = 0 . \\ F_f = \mu_s F_N \quad (\text{max. static friction}) \end{cases}$

$\therefore \begin{cases} F_N \sin\theta + \mu_s F_N \cos\theta = m\dfrac{v^2}{R} & ① \\ F_N \cos\theta - \mu_s F_N \sin\theta = mg . & ② \end{cases}$

0.5

$\dfrac{①}{②}$: $\dfrac{\sin\theta + \mu_s \cos\theta}{\cos\theta - \mu_s \sin\theta} = \dfrac{v^2}{Rg}$.

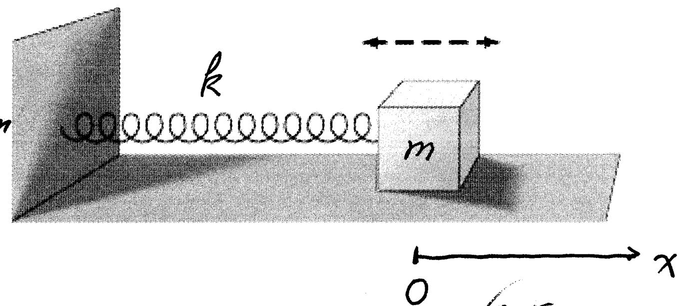
$v = \sqrt{Rg \dfrac{\sin\theta + \mu_s \cos\theta}{\cos\theta - \mu_s \sin\theta}} = \sqrt{150 \times 9.8 \dfrac{\sin 10.7^\circ + 0.1 \times \cos 10.7^\circ}{\cos 10.7^\circ - 0.1 \times \sin 10.7^\circ}}$

$= 20.8\ m/s$

10. A 0.600-kg wood block is firmly attached to a very light horizontal spring k=200 N/m as shown in the figure . It is noted that the block-spring system, when compressed 5.00 cm and released, stretches out 4.00 cm beyond the equilibrium position before stopping and turning back. What is the coefficient of kinetic friction between the block and the table?

$m = 0.6\ kg, \quad k = 200\ N/m$

$X_c = -0.05\ m, \quad X_s = 0.04\ m$



(0.5)

(0.5) $F_f = \mu_k F_N = \mu_k mg$

(2) Generalized work-energy principle:

$$W_N = \Delta E$$

(1) $$-\mu_k mg \cdot (X_s - X_c) = \frac{1}{2} k X_s^2 - \frac{1}{2} k X_c^2$$

(1) $$\mu_k = \frac{-k(X_s^2 - X_c^2)}{2mg(X_s - X_c)} = \frac{-k(X_s + X_c)}{2mg}$$

$$= \frac{-200(0.04 - 0.05)}{2 \times 0.6 \times 9.8}$$

$$= 0.17.$$