PHYS 101 Midterm Examination #1 (version D)

Feb. 11, 2011

Time: 50 minutes

Last Name : Key

First Name : ______________________

Student No. : ______________________

Computing ID : ______________________

Tutorial Section : ______________________

	score	*Maximum*
Multiple Choice		*5*
Written # 1		*5*
Written # 2		*5*
Written # 3		*5*
Total		*20*

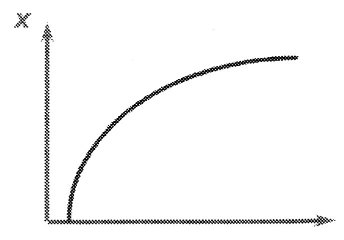
Part I (Multiple choice questions. 1 mark each.)

A

1. When throwing a ball straight up, which of the following is true about its velocity *v* and its acceleration *a* at the highest point in its path?
   (A) $v = 0$ but $a \neq 0$
   (B) $v \neq 0$ but $a = 0$
   (C) both $v = 0$ and $a = 0$
   (D) both $v \neq 0$ and $a \neq 0$
   (E) none of the above.

B

2. The graph of position vs. time for a car is given below. What can you say about the velocity of the car over time?
   (A) it speeds up all the time
   (B) it slows down all the time
   (C) it moves at constant velocity
   (D) it speeds up first and then slows down
   (E) it slows down first and then speeds up



E

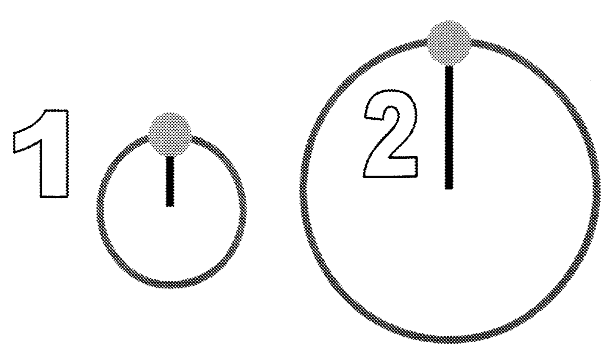
3. An object is in a uniform circular motion. Which of the following must be true?
   (A) A net force pointing along the direction of motion is acting on the object.
   (B) The acceleration of the object is constant but not zero.
   (C) The velocity of the object is constant.
   (D) The acceleration of the object is zero.
   (E) The speed of the object is constant.

C

4. The condition for mechanical energy to be conserved is
   (A) It's a closed system.
   (B) The net force is zero.
   (C) No nonconservative work.
   (D) The mechanical energy is never conserved.
   (E) The mechanical energy is always conserved.

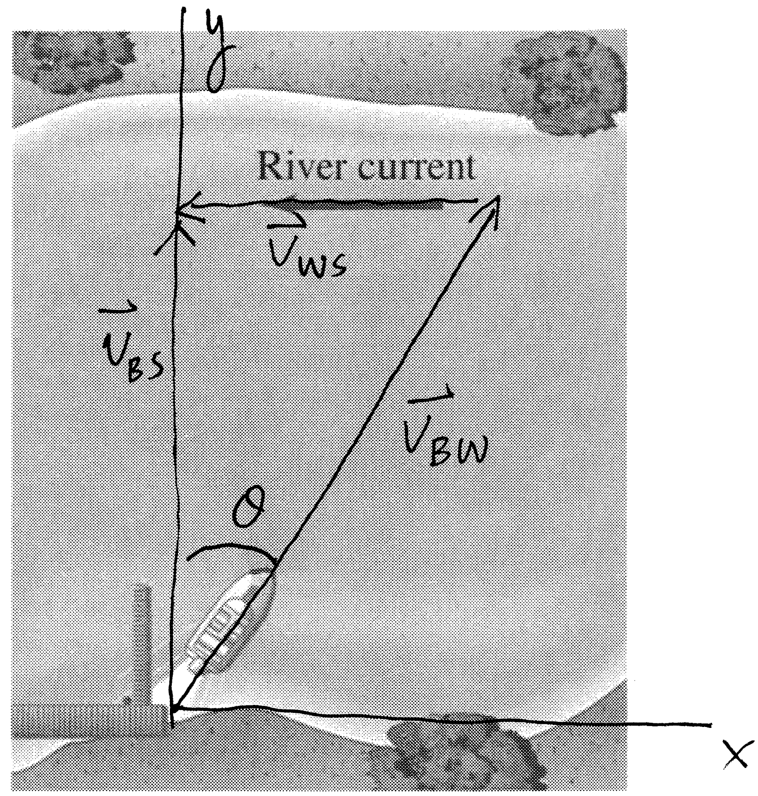
D

5. Two equal-mass rocks tied to strings are whirled in horizontal circles. The radius of circle 2 is twice that of circle 1. If the period of motion is the same for both rocks, what is the tension in cord 2 compared to cord 1?
   (A) $T_2 = 1/4\ T_1$
   (B) $T_2 = 1/2\ T_1$
   (C) $T_2 = T_1$
   (D) $T_2 = 2\ T_1$
   (E) $T_2 = 4\ T_1$



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

6. A boat's speed in still water is 2.00 m/s. If the boat is to travel directly across a river whose current has speed 1.20 m/s,
(a) at what upstream angle must the boat head (indicate the angle in the figure)?
(b) if the river is 100 m wide, how long does it take for the boat to reach the other side of the river?



$v_{BW} = 2.00$ m/s

$v_{WS} = 1.200$ m/s

$\vec{v}_{BS} = \vec{v}_{BW} + \vec{v}_{WS}$

(a). $\theta = \sin^{-1} \frac{v_{WS}}{v_{BW}}$

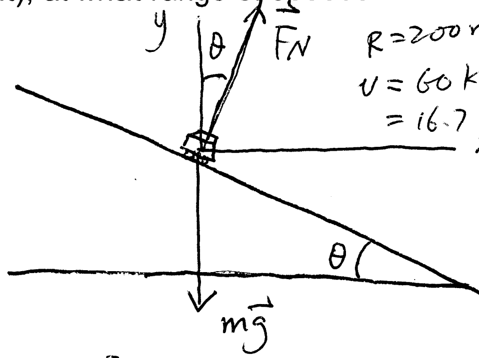
$= \sin^{-1} \frac{1.20}{2.00}$

$= 36.9°$

(b). $\Delta t = \frac{\Delta y}{v_{BSy}} = \frac{100}{v_{BW} \cos\theta}$

$\Delta t = \frac{100}{2.00 \cos 36.9°} = 62.5$ sec.

7. (**Show free-body-diagrams!**). At the entrance of a free way, a curve of radius 200m 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 (~~wet~~ icy pavement), at what range of speeds can a car safely handle the curve?



$R = 200\,m$. $v = 60\,km/h = 16.7\,m/s$

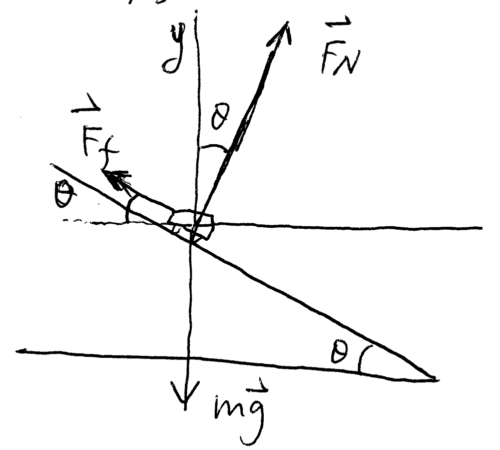
(a). No friction.

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

x-comp: $F_N \sin\theta = m\frac{v^2}{R}$. ①

y-comp: $F_N \cos\theta - mg = 0$ ②

Solve for θ: $\theta = \tan^{-1}\frac{v^2}{Rg} = \tan^{-1}\frac{(16.7)^2}{200\times 9.8} = 8.10^\circ$



(b). Case 1: too slow

x-comp: $F_N \sin\theta - F_f \cos\theta = m\frac{v^2}{R}$

y-comp: $F_N \cos\theta + F_f \sin\theta - mg = 0$.

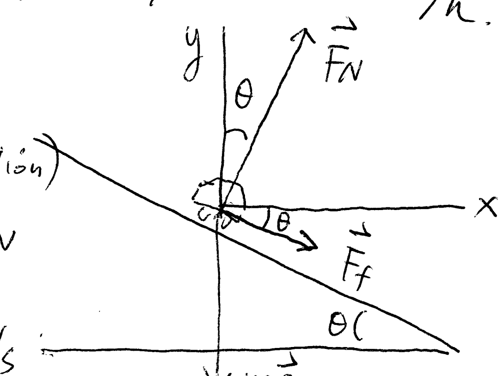
Max friction: $F_f = \mu_s F_N$.

$F_N \sin\theta - \mu_s F_N \cos\theta = m\frac{v^2}{R}$ ③

$F_N \cos\theta + \mu_s F_N \sin\theta = mg$. ④

$\frac{③}{④}$: $\frac{\sin\theta - \mu_s\cos\theta}{\cos\theta + \mu_s \sin\theta} = \frac{v^2}{Rg}$, $v = \sqrt{\frac{\sin\theta - \mu_s\cos\theta}{\cos\theta + \mu_s\sin\theta}\cdot Rg}$

$v = \sqrt{\frac{\sin 8.1^\circ - 0.1\cdot\cos 8.1^\circ}{\cos 8.1^\circ + 0.1 \sin 8.1^\circ}(200)(9.8)} = 9.04\,m/s = 32.6\,km/h$.



Case 2: Too fast.

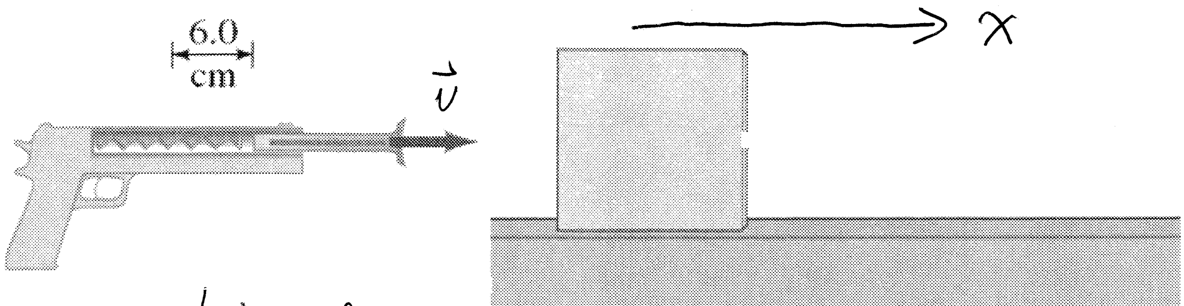
$F_N \sin\theta + F_f \cos\theta = m\frac{v^2}{R}$. (Max. friction) $F_f = \mu_s F_N$

$F_N \cos\theta - F_f \sin\theta - mg = 0$.

Solve for v: $v = \sqrt{\frac{\sin\theta + \mu_s\cos\theta}{\cos\theta - \mu\sin\theta}\cdot Rg} = 22.0\,m/s = 79\,km/h$.

$33\,km/h < v < 79\,km/h$

8. A dart of mass 0.200 kg is pressed against the spring of a toy dart gun. The spring (with spring stiffness constant k = 500 N/m and ignorable mass) is compressed 6.0 cm and released.
(a) What speed does the dart acquire as it leaves the dart gun?
(b) The dart hits and sticks to a block of mass 0.300kg which is at rest on a table. What speed does the block acquire?
(c) If the coefficient of kinetic friction between the block and the table is 0.18, how far will the block (with the dart) travel before it stops?



(a). Conservation of M.E.

$$\frac{1}{2}kX^2 = \frac{1}{2}mv^2, \quad v = X\sqrt{\frac{k}{m}} = 0.06\sqrt{\frac{500}{0.2}} = 3.00 \text{ m/s}$$

(b). Conservation of momentum (x-comp).

$$mv = (m+M)v'$$

$$v' = \frac{mv}{m+M} = \frac{0.2 \times 3}{0.2 + 0.3} = 1.20 \text{ m/s}$$

(c). Work-energy principle: $W_{net} = \Delta KE$

$$-F_f \, \Delta x = 0 - \frac{1}{2}(m+M)v'^2$$

$$F_f = F_N \mu_k = (m+M)g\mu_k$$

$$\mu_k (m+M) g \, \Delta x = \frac{1}{2}(m+M)v'^2$$

$$\Delta x = \frac{v'^2}{2\mu_k g} = \frac{(1.2)^2}{2 \times 0.18 \times 9.8} = 0.408 \text{ m}$$

$$\approx 0.41 \text{ m}$$