PHYS 100 Midterm 3, November 18, 2005 **Version 3A**

Last Name Key

First Name_____

Student ID_____

Signature_____

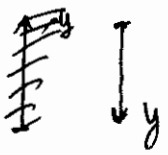
Part 1: Multiple Choice (2x5=10 marks) A D C E B

For each of the following five questions, please circle one answer only.

(1) A tennis racket exerts a force of 24 N on a 55 g tennis ball to change its velocity from 15 m/s north to 25 m/s south. Over what period of time does this change of momentum take place?

A) 0.092 s
B) 0.023 s
C) 92 s
D) 23 s
E) 10.9 s

$$F \cdot \Delta t = \Delta p$$
$$= m \cdot \Delta v$$
$$\Delta t = \frac{m \Delta v}{F}$$
$$= \frac{0.055\ kg \cdot [25 - (-15)]\ m/s}{24\ N}$$
$$= 0.092\ s.$$

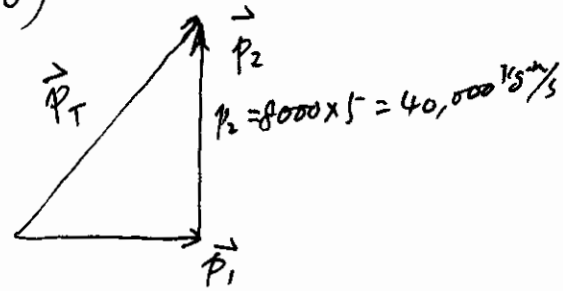


(2) A car of mass 2000 kg traveling east at 15 m/s collides at an intersection with a truck of 8000 kg traveling north at 5 m/s. The car and truck stick together. What is the speed of the wreckage just after the collision? (Ignore friction between the road and tires).

A) 10 m/s
B) 40 m/s
C) 20 m/s
D) 5 m/s
E) 14 m/s

Conservation of momentum. ($\vec{F}_{net}^{ext} = 0$)

$$\vec{p}_T = \vec{p}_1 + \vec{p}_2$$
$$p_T = \sqrt{p_1^2 + p_2^2} = 50{,}000\ kg \cdot m/s$$
$$v_T = \frac{p_T}{m_1 + m_2} = \frac{50{,}000}{10{,}000} = 5\ m/s$$



(3) A satellite is moving in a circular orbit around the earth. Which statement is NOT true?

A) The gravitational force is perpendicular to the velocity of the satellite.
B) The speed of the satellite is unchanged.
C) The velocity of the satellite is unchanged.
D) The gravitational force equals the centripetal force.
E) The magnitude of acceleration is unchanged.

(4) The net force on a moving object is suddenly reduced to zero. As a consequence, the object

A) stops abruptly.
B) changes velocity in an unknown manner.
C) stops during a short time interval.
D) changes direction.
(E) continues at constant velocity.

(5) A baseball of mass 0.190 kg moving at 30.0 m/s strikes the glove of a catcher. The glove recoils a distance of 8.00 cm. The magnitude of the average force applied by the ball on the glove is

A) 71.3 N
(B) 1.07×10^3 N
C) 0.731 N
D) 10.7 N
E) 2.14×10^3 N

$W = \Delta KE$

$F \cdot \Delta x = \frac{1}{2} m (v_f^2 - v_i^2) = \frac{1}{2} \times 0.19 (0 - 30^2)$

$F = \frac{|\Delta KE|}{|\Delta x|} = \frac{0.5 \times 0.19 \times 30^2}{0.08\ m} = 1.07 \times 10^3\ N$

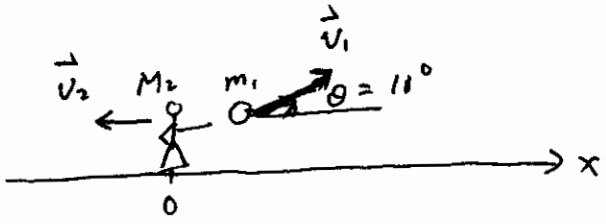
Part 2: Written questions (3x5=15 marks):

Please show complete solutions and explain your reasoning, stating any principles that you have used.

Written question 1 (5 marks):
A young hockey player stands at rest on the ice holding a 1.2 kg helmet. The player tosses the helmet with a speed of 6.0 m/s in a direction 11° above the horizontal, and recoils with a speed of 0.20 m/s. What is the mass of the hockey player?

Net external force = 0.
Momentum is conserved. $\vec{P}_i = \vec{P}_f = 0$

$m_1 v_1 \cos\theta$



x-component of net external force = 0. $F_x = 0$.

∴ x-component of total momentum is conserved. $P_{xi} = P_{xf} = 0$

i.e. $m_1 v_1 \cos\theta - M_2 v_2 = 0$

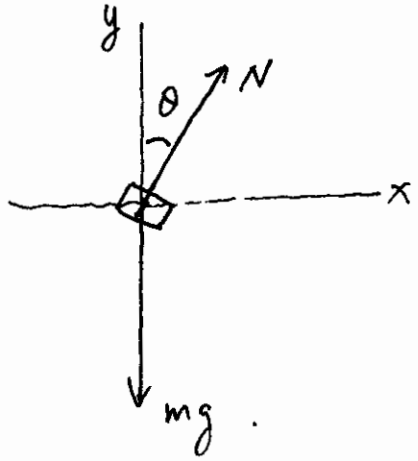
$M_2 = \frac{m_1 v_1 \cos\theta}{v_2} = \frac{1.2 \times 6 \times \cos 11°}{0.2} = 35.3\ kg$

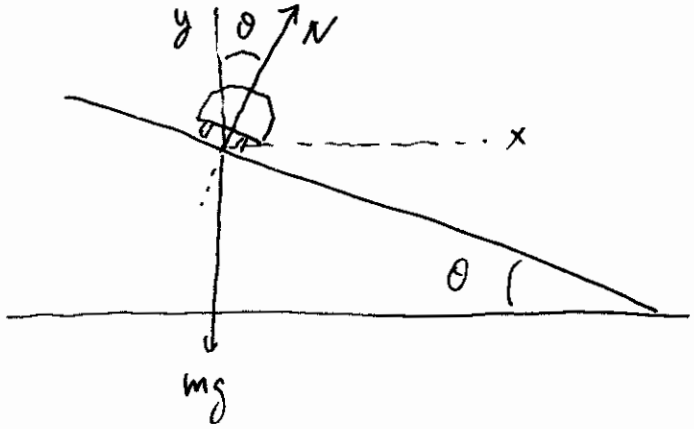
Written Question 2 (5 marks):

A car goes around a curve on a road that is banked at an angle of 20.0°. Even though the road is slick, the car will stay on the road without any friction between its tires and the road when its speed is 25.0 m/s. What is the radius of the curve? (show the free-body diagram).

FBD.

$\theta = 20°$





$\vec{F} = m\vec{a}$: x-component : $N\sin\theta = m\frac{v^2}{R}$ ①

y-component : $N\cos\theta - mg = 0$ ②

from ②: $N = \frac{mg}{\cos\theta}$

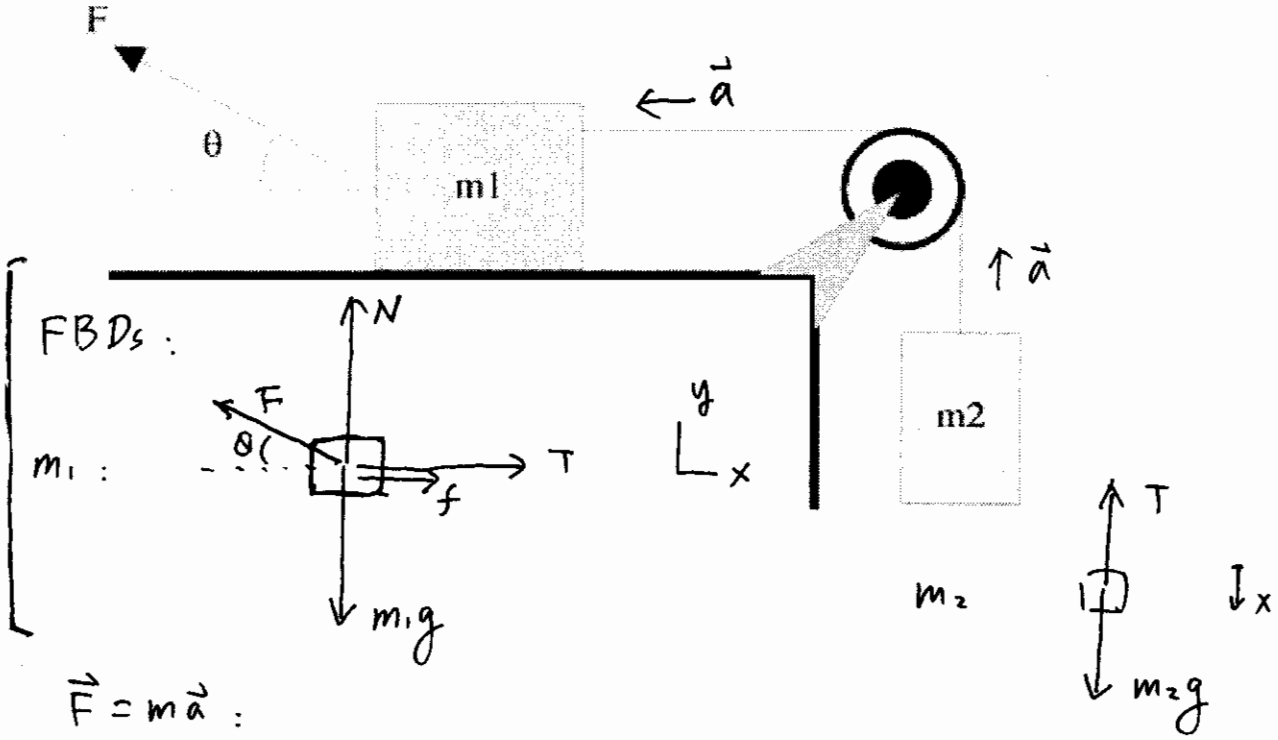
Subs into ①: $\frac{mg\sin\theta}{\cos\theta} = m\frac{v^2}{R}$

$R = \frac{v^2\cos\theta}{g\sin\theta}$

$= \frac{25^2 \times \cos 20°}{9.8 \times \sin 20°}$

$= 175$ m.

Written Question 3 (5 marks):
A 25- *kg* block (m_1) is on a horizontal surface, connected to a 5.0- *kg* block (m_2) by a massless string as shown in the Figure. The pulley is massless and frictionless. A force of 250 *N* acts on m_1 at an angle of 30°. The coefficient of kinetic friction between m_1 and the surface is 0.20. Determine the upward acceleration of m_2. (Include free-body diagrams)



(2/5)

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

m_1 : x- : $T + f - F\cos\theta = m_1 a$ ① ✓

y- : $F\sin\theta + N - m_1 g = 0 \Rightarrow N = m_1 g - F\sin\theta$ ② ✓

$f = \mu_k N = \mu_k (m_1 g - F\sin\theta)$ ③ ✓

(2/5)

③ → ① : $T + \mu_k (m_1 g - F\sin\theta) - F\cos\theta = m_1 a$. ④

m_2 : $m_2 g - T = m_2 a$ ⑤ ✓

(1/5)

④ + ⑤ : $\mu_k (m_1 g - F\sin\theta) - F\cos\theta + m_2 g = m_1 a + m_2 a$

$$a = \frac{\mu_k (m_1 g - F\sin\theta) - F\cos\theta + m_2 g}{m_1 + m_2}$$

$$= \frac{0.2(25 \times 9.8 - 250 \cdot \sin 30°) - 250\cos 30° + 5 \times 9.8}{25 + 5}$$

$$= -4.78 \ m/s^2$$