PHYS 100 Midterm Examination #2 (vers. 2A)

Final Key.

March 16, 2007

Time: 50 minutes

Last Name ________________________

First Name ________________________

Student No. ________________________

Computing ID ________________________

ALL Section________________________

	score	***maximum***
Multiple Choice		***9***
Written # 1		***5***
Written # 2		***5***
Written # 3		***5***
Total		***24***

 ABBDC

Part I (Multiple choice questions). For each of the following five questions, **please circle one answer only**.

1. A man is lowering a bucket into a well with a constant velocity. The force exerted by the rope on the bucket is (ignore air resistance)

A

A) equal to the bucket's weight
B) greater than the bucket's weight
C) less than the bucket's weight, but not zero
D) zero
E) proportional to the velocity of the bucket

2. A golf club exerts an average force of 1000 N on a 0.045-kg golf ball which is initially at rest. The club is in contact with the ball for 1.8 ms. What is the speed of the golf ball as it leaves the tee?

B

A) 35 m/s
B) 40 m/s
C) 45 m/s
D) 50 m/s
E) 12 m/s

3. 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

B

A) 667 N
B) 600 N
C) 60 N
D) 3 N
E) 0.15 N

4. Impulse is equal to ______ of the object.

D

A) the change in kinetic energy
B) the kinetic energy
C) the momentum
D) the change in momentum
E) The net force exerted on the object multiplied by its displacement

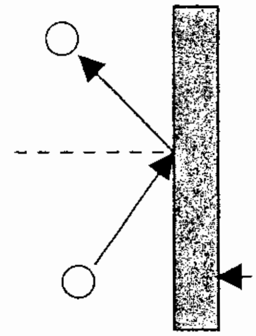
5. At her highest point, a girl on a swing is 2.50 m above the ground and at her lowest point, she is 1.00 m above the ground. What is her maximum speed?

C

A) 3.83 m/s
B) 4.43 m/s
C) 5.42 m/s
D) 7.00 m/s
E) 8.29 m/s

EDBD

6. A billiard ball hits the cushion of a pool table and bounces as indicated. The change in momentum, "P is a vector which is:



A) directed parallel to the cushion
B) directed along the incident ball direction
C) directed along the outgoing ball direction
E D) directed perpendicular to the cushion, to the right
(E) directed perpendicular to the cushion, to the left.

7. Which of the following statements BEST describes a perfectly ELASTIC collision?
A) Momentum is conserved.
B) Kinetic energy is conserved.
D C) Momentum is conserved but kinetic energy is not.
(D) Momentum AND kinetic energy are conserved.
E) Momentum AND potential energy are conserved.

8. Conservation of mechanical energy ("KE + "PE = 0) only holds if:
A) There is no work done on the system.
(B) There is no non conservative work.
B C) Momentum is NOT conserved.
D) None of the above.
E) All of the above.

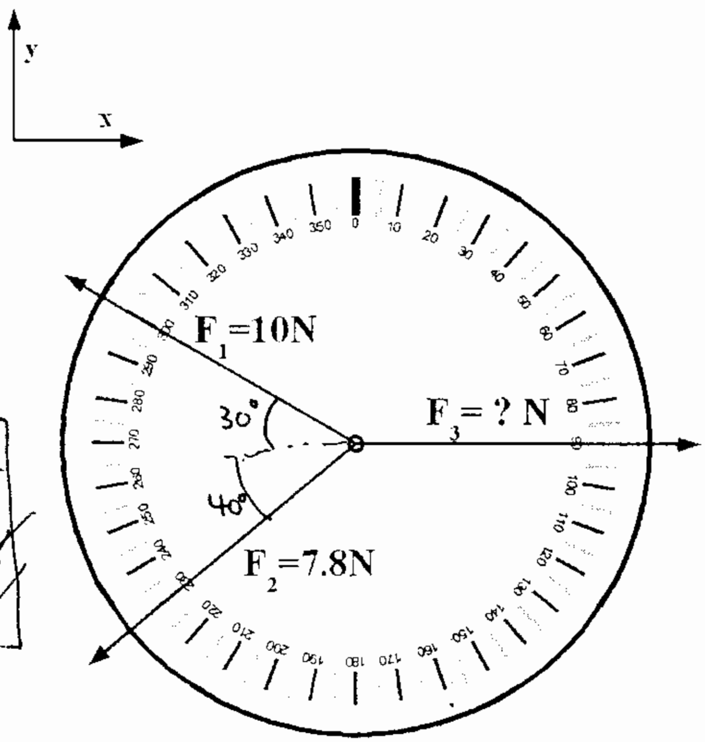
9. Which quantity is NOT a vector.
A) Force
B) Impulse
D C) Momentum
(D) Kinetic energy
E) Velocity

CONTINUE TO WRITTEN QUESTIONS ON NEXT PAGE.

Part II (Full solution questions).

1. The diagram below illustrates three forces, (F_1, F_2 and F_3), pulling **AWAY** from a single point in various directions. The system is in **EQUILIBRIUM** (F_{NET}=0N), and the angles of interest can be read by using the paper protractor provided in the figure.

5 marks Total.



~~0.5 mark for recognizing angles.~~

a) Calculate the magnitude of the x and y (using the given coordinate system) component of F_1 and F_2.

2 marks.

$\vec{F}_1 = (-10\cos 30\,\hat{x} + 10\sin 30\,\hat{y})\,N$

$\vec{F}_1 = (-8.7\,\hat{x} + 5.0\,\hat{y})\,N$ [1 mark]

$\vec{F}_2 = (-7.8\cos 40\,\hat{x} - 7.8\sin 40\,\hat{y})\,N$

$\vec{F}_2 = (-6.0\,\hat{x} - 5.0\,\hat{y})\,N$ [1 mark]

b) Using the equilibrium condition and vector components find the magnitude of F_3.

equilibrium: $\sum \vec{F}_{NET} = 0$ [1 mark]

3 marks.

$\sum \vec{F}_x = 0 = F_{1x} + F_{2x} + F_{3x}$

$0 = -8.7 - 6.0 + F_{3x}$ [1 mark]

$\therefore F_{3x} = 8.7 + 6.0$

$F_{3x} = 14.7\,N$

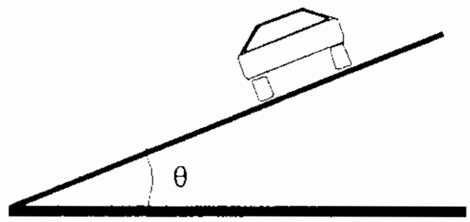
also $\sum F_y = 0 = F_{1y} + F_{2y} + F_{3y}$

[1 mark] $0 = 5 - 5 + F_{3y}$

$\therefore F_{3y} = 0.$

Magnitude of F_3 is 14.7 N.

2.Highway curves are usually banked (tilted inward) at an angle , such that the horizontal component of the normal force equals the required centripetal force.



F.B.D.

1 mark

a_c to the left.

a) Find the proper banking angle for the car moving at 60km/h to go around a circular curve 100 m in radius.

3 marks

$60\ km/hr = 16.7\ m/s$, $a_c = v^2/r$.

$r = 100\ m$
$v = 16.7\ m/s$
$\theta = ?$

NII

$\Sigma F_y = ma_y$
$F_N\cos\theta - mg = 0$
$F_N = \frac{mg}{\cos\theta}$.

$\Sigma F_x = ma_x$
$-F_N\sin\theta = -\frac{mv^2}{r}$

1 mark

① $F_N\sin\theta = \frac{mv^2}{r}$.

② $F_N = \frac{mg}{\cos\theta}$.

sub ① → ②.

$\frac{mg\sin\theta}{\cos\theta} = \frac{mv^2}{r}$

$\tan\theta = \frac{v^2}{gr}$

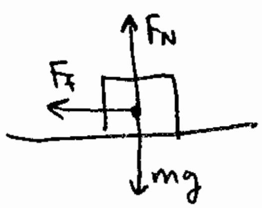
$\theta = \tan^{-1}\left(\frac{v^2}{gr}\right)$

$\boxed{\theta = 15.8^\circ}$

1 mark

b) If the curve were not banked, what coefficient of friction would be required between the tires and the road?

a_c to the left.



1 mark.

NII

$\Sigma F_x = ma_x$
$-F_f = -\frac{mv^2}{r}$

$\Sigma F_y = ma_y$
$F_N - mg = 0$

① $F_f = \frac{mv^2}{r}$

② $F_N = mg$

2 marks.

③ $F_f = \mu F_N$

② ⇒ ③ $F_f = \mu mg$ ④ 1 mark.

④ ⇒ ① $\mu mg = \frac{mv^2}{r}$

$\mu = \frac{v^2}{gr}$ $\boxed{\mu = 0.28}$

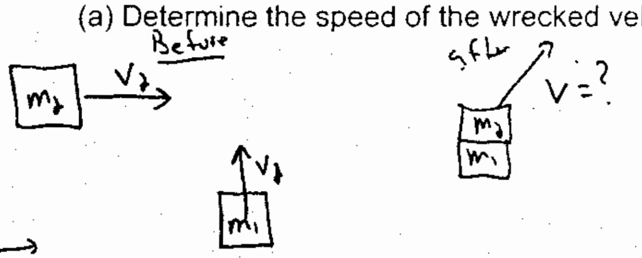
2A

3. A car with a mass of 1000 kg and a speed of 20 m/s heading north approaches an intersection. At the same time, a minivan with a mass of 1500 kg and a speed of 10 m/s heading east is also approaching the intersection. The car and the minivan collide and stick together.

$m_1 = 1000\,kg$ $v_1 = 20\,m/s, N$

$m_2 = 1500\,kg$ $v_2 = 10\,m/s, E$

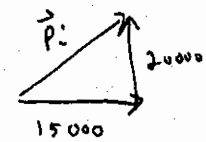
(a) Determine the speed of the wrecked vehicles just after the collision. (inelastic collision)



finding $\vec{p}_i$:

$p_{ix} = m_2 v_2 = 15\,000\,kg\,m/s$

$p_{iy} = m_1 v_1 = 20\,000\,kg\,m/s$ (1)



$|\vec{p}_i| = \sqrt{15000^2 + 20000^2}$

$= 25000\,kg\,m/s$

$\vec{F}_{ext}\Delta t = \Delta\vec{p}$, but $\vec{F}_{ext} = 0$ (1)

$\therefore \Delta\vec{p} = 0.$

$\therefore \vec{p}_i = \vec{p}_f$

since we asked for speed, direction does not matter.

$|\vec{p}_i| = |\vec{p}_f|$

$25000 = (m_1 + m_2)v$ (1)

$v = \frac{25000}{(1000+1500)} = 10\,m/s.$

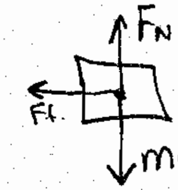
$v = 10\,m/s$

3 marks

(b) After the collision, the wrecked vehicles will skid on the road and finally stop because of the friction between the tires and the road. If the coefficient of kinetic friction is 0.4, how far will the vehicles skid, in meters, before they stop?

$W_{NET} = \Delta KE$

$\vec{F}_{NET} = \vec{F}_f = \mu F_N$ ← due to friction.



$\therefore mg = F_N$

$\vec{F}_{NET}\cdot\Delta\vec{d} = \Delta KE$ (1)

note $m = m_1 + m_2$

since the friction points in the opposite direction as $\Delta\vec{d}$: $\vec{F}_{NET}\cdot\Delta\vec{d} = -F_{NET}\Delta d$

2 marks

$-F_{NET}\Delta d = \Delta KE$

$-\mu F_N \Delta d = \Delta KE$

$-\mu \cancel{m} g \Delta d = \frac{1}{2}\cancel{m}(v_f^2 - v_o^2)$ (1)

$v_f = 0$; stops

$v_o = 10\,m/s$ (from a).

$-\mu g \Delta d = -\frac{1}{2}v_o^2$

$\Delta d = \frac{1}{2}\frac{v_o^2}{\mu g} = \frac{1}{2}\frac{(10)^2}{(0.4)(9.81\,m/s^2)}$

$\Delta d = 12.7$

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Last Name ______________________

First Name ______________________

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ALL Section______________________

	score	*maximum*
Multiple Choice		*9*
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 D D C A D

Part I (Multiple choice questions). For each of the following five questions, **please circle one answer only**.

1. A man is lowering a bucket into a well with a constant velocity. The force exerted by the rope on the bucket is (ignore air resistance)
   A) zero
   B) proportional to the velocity of the bucket
   C) less than the bucket's weight, but not zero
   D) equal to the bucket's weight
   E) greater than the bucket's weight

D

2. A golf club exerts an average force of 1500 N on a 0.045-kg golf ball which is initially at rest. The club is in contact with the ball for 1.5 ms. What is the speed of the golf ball as it leaves the tee?
   A) 35 m/s
   B) 40 m/s
   C) 45 m/s
   D) 50 m/s
   E) 12 m/s

D

3. A baseball of mass 0.18 kg moving at 25.0 m/s strikes the glove of a catcher. The glove recoils a distance of 4.0 cm. The magnitude of the average force applied by the ball on the glove is
   A)767 N
   B)800 N
   C)1406 N
   D)3 N
   E)0.15 N

C

4. Impulse is equal to ______ of the object.

   A) the change in momentum
   B) the momentum
   C) the kinetic energy
   D) the change in kinetic energy
   E) The net force exerted on the object multiplied by its displacement

A

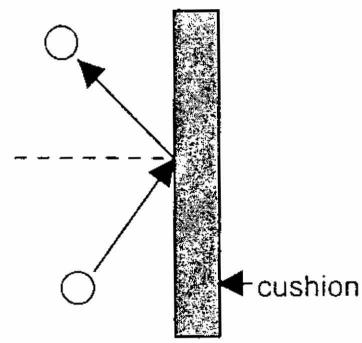
5. At her highest point, a girl on a swing is 3.50 m above the ground and at her lowest point, she is 1.00 m above the ground. What is her maximum speed?
   A) 3.83 m/s
   B) 4.43 m/s
   C) 5.42 m/s
   D) 7.00 m/s
   E) 8.29 m/s

D

 C D C B

6. A billiard ball hits the cushion of a pool table and bounces as indicated. The change in momentum, "**P** is a vector which is:

A) directed along the incident ball direction.
B) directed along the outgoing ball direction.
C C) directed perpendicular to the cushion, to the left.
D) directed perpendicular to the cushion, to the right.
E) directed parallel to the cushion.



7. Which of the following statements BEST describes a perfectly ELASTIC collision?
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D) Momentum AND kinetic energy are conserved.
E) Momentum is conserved but kinetic energy is not.

8. Conservation of mechanical energy ("KE + "PE = 0) only holds if:
A) Momentum is NOT conserved.
B) There is no work done on the system.
C C) There is no non conservative work.
D) None of the above.
E) All of the above.

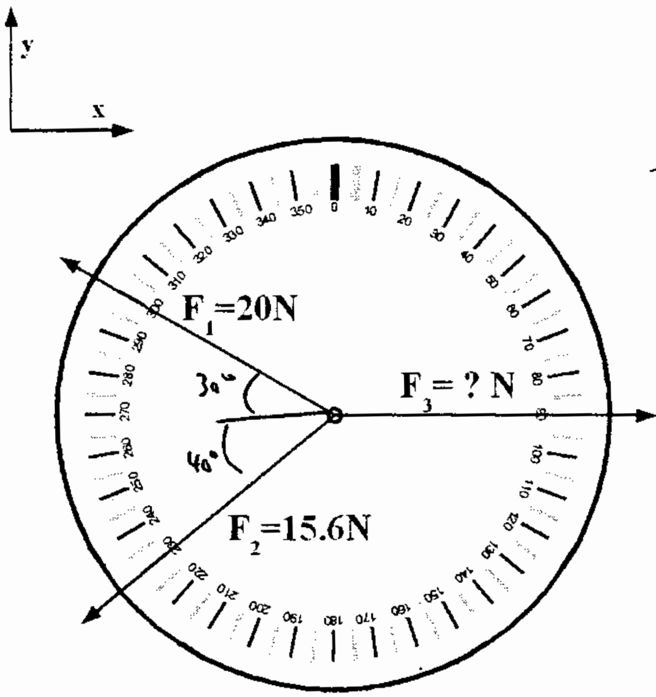
9. Which quantity is NOT a vector.
A) Force
B B) Kinetic energy
C) Momentum
D) Impulse
E) Velocity

CONTINUE TO WRITTEN QUESTIONS ON NEXT PAGE.

Part II (Full solution questions).

1.The diagram below illustrates three forces, (F_1, F_2 and F_3), pulling AWAY from a single point in various directions. The system is in **EQUILIBRIUM** (F_{NET}=0N), and the angles of interest can be read by using the paper protractor provided in the figure.

5 marks Total



a) Calculate the magnitude of the x and y (using the given coordinate system) component of F_1 and F_2.

$\vec{F}_1 = (-20\cos 30° \hat{x} + 20\sin 30° \hat{y})$ N

2 marks $\vec{F}_1 = (-17.3\hat{x} + 10\hat{y})$ N [1 mark]

$\vec{F}_2 = (-15.6\cos 40\hat{x} - 15.6\sin 40\hat{y})$ N

$\vec{F}_2 = (-12\hat{x} - 10\hat{y})$ N. [1 mark]

b) Using the equilibrium condition and vector components find the magnitude of F_3.

equilibrium $\sum \vec{F}_{NET} = 0$ [1 mark]

3 marks

$\sum F_x = 0 = F_{1x} + F_{2x} + F_{3x}$

$0 = -17.3 - 12 + F_{3x}$

$F_{3x} = 17.3 + 12$

$F_{3x} = 29.3$ N [1 mark]

$\sum F_y = 0 = F_{1y} + F_{2y} + F_{3y}$

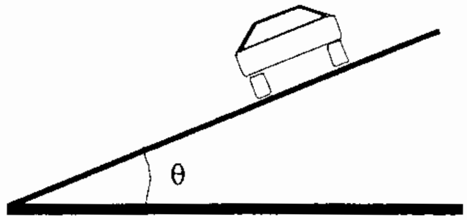
$0 = 10 - 10 + F_{3y}$

$\therefore F_{3y} = 0.$ [1 mark.]

$\vec{F}_3 = 29.3\hat{x} + 0\hat{y}$

$\therefore$ The magnitude is 29.3 N.

Highway curves are usually banked (tilted inward) at an angle , such that the horizontal component of the normal force equals the required centripetal force.

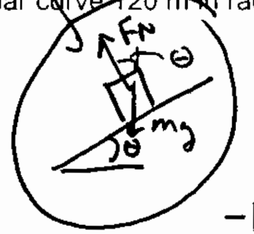


FBD

1 mark

3 marks

a) Find the proper banking angle for the car moving at 80km/h to go around a circular curve 120 m in radius.



$80 Km/hr = 22.2 m/s$ $\quad a_c = v^2/r$.

NII

$\sum F_x = ma_x$ $\quad \sum F_y = ma_y$

$-F_N \sin\theta = -mv^2/r$ $\quad F_N \cos\theta - mg = 0$

(1) $F_N \sin\theta = mv^2/r$ $\quad$ (2) $F_N \cos\theta = mg$.

1 mark. $\quad$ (2) ⇒ (1). $\quad \frac{mg \sin\theta}{\cos\theta} = mv^2/r$.

$\tan\theta = \frac{v^2}{gr}$

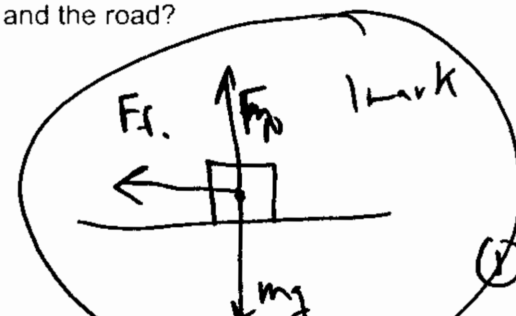
$\theta = \tan^{-1}\left(\frac{v^2}{gr}\right)$

$\boxed{\theta = 22.8°}$

1 mark.

3

b) If the curve were not banked, what coefficient of friction would be required between the tires and the road?



$\sum F_x = ma_x$ $\quad \sum F_y = ma_y$

$-F_f = -mv^2/r$ $\quad F_N - mg = 0$

(1) $F_f = mv^2/r$ $\quad$ (2) $F_N = mg$

(3) $F_f = \mu F_N$ $\quad$ 1 mark.

2

2 marks

(2) ⇒ (3) $\quad F_f = \mu mg$. (4)

(4) ⇒ (1)

$\mu mg = mv^2/r$

$\boxed{\mu = 0.41}$

$\mu = \frac{v^2}{gr} = 0.41$ or 0.42

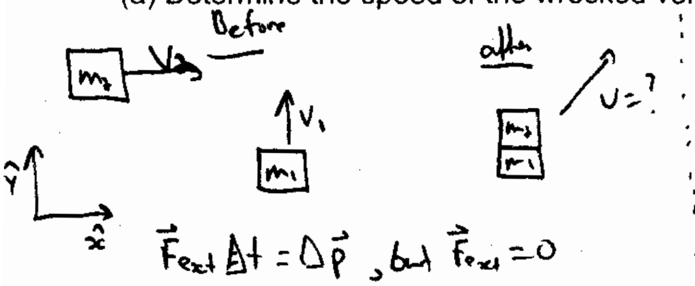
2B.

3.A car with a mass of 2000 kg and a speed of 30 m/s heading north approaches an intersection. At the same time, a minivan with a mass of 1000 kg and a speed of 40 m/s heading east is also approaching the intersection. The car and the minivan collide and stick together.

$m_1 = 2000\,kg$, $\vec{v}_1 = 30\,m/s$, N

$m_2 = 1000\,kg$, $\vec{v}_2 = 40\,m/s$

(a) Determine the speed of the wrecked vehicles just after the collision.



$\vec{F}_{ext}\Delta t = \Delta\vec{p}$, but $\vec{F}_{ext} = 0$

$\therefore \Delta\vec{p} = 0$ (1)

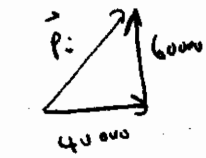
$\therefore \vec{p}_i = \vec{p}_f$

3 marks

finding $\vec{p}_i$:

$p_{ix} = m_2 v_2 = 40000\ kg\,m/s$

$p_{iy} = m_1 v_1 = 60000\ kg\,m/s$ (1)



$|\vec{p}_i| = \sqrt{40000^2 + 60000^2}$

$= 72111\ kg\,m/s$

since we asked for speed we can ignore direction.

$|\vec{p}_i| = |\vec{p}_f|$ (1)

$72111 = (m_1 + m_2)v$

$v = \frac{72111}{m_1 + m_2}$

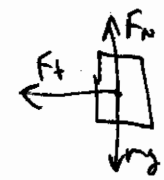
$v = 24\,m/s$

(b) After the collision, the wrecked vehicles will skid on the road and finally stop because of the friction between the tires and the road. If the coefficient of kinetic friction is 0.35, how far will the vehicles skid, in meters, before they stop?

$W_{NET} = \Delta KE$

$\vec{F}_{NET} \cdot \Delta\vec{d} = \Delta KE$ (1)

$\vec{F}_{NET} = \vec{F}_f = \mu \vec{F}_N$ (due to friction)



$\therefore F_N = mg$

note $m = m_1 + m_2$

since the friction points in the opposite direction as $\Delta\vec{d}$ $\vec{F}_{NET} \cdot \Delta\vec{d} = -|F_{NET}||\Delta d|$

2 marks.

$\therefore -F_{NET}\Delta d = \Delta KE$

$-\mu F_N \Delta d = \Delta KE$

$-\mu m g \Delta d = \frac{1}{2} m (v_f^2 - v_0^2)$

$v_f = 0$; stopped.

(1) $+\mu g \Delta d = \frac{1}{2} v_0^2$

$\Delta d = \frac{1}{2}\frac{v_0^2}{\mu g} = \frac{(24)^2}{2(0.35)(9.81)}$

$\Delta d = 84\,m$