PHYS 101 Midterm Examination #1 (version A)

Feb. 13, 2009

Time: 50 minutes

Last Name : Key

First Name : _____

Student No. : _____

Computing ID : _____

	score	*maximum*
Multiple Choice		*5*
Written # 1		*5*
Written # 2		*5*
Written # 3		*5*
Written # 4		*5*
Total		*25*

C D E A B

Part I (Multiple choice questions. 1 mark each. Please circle ***one*** answer for each question).

C (1) An object is moving at a constant velocity. Which of the following statements must be true?

(A) A constant force is being applied in the direction of motion.
(B) There is no frictional force acting on the object.
(C) The net force acting on the object is zero.
(D) There are no forces acting on the object.
(E) The net force acting on the object depends on the magnitude of the velocity.

D (2) An object is in a uniform circular motion. Which of the following statements must be true?

(A) A net force pointing along the direction of motion is acting on the object.
(B) The net force acting on the object is zero.
(C) The velocity of the object is constant.
(D) A net force pointing towards the center of the circle acts on the object.
(E) The acceleration of the object is zero.

E (3) When a parachutist jumps from an airplane, he eventually reaches a constant speed, called the terminal velocity. This means that

A) the acceleration is equal to g.
B) the force of air resistance is equal to zero.
C) the effect of gravity has died down.
D) the effect of gravity increases as he becomes closer to the ground.
E) the magnitude of drag force is equal to the weight of the parachutist.

A (4) 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) 600 N
B) 667 N
C) 60 N
D) 3 N
E) 0.15 N

$W = \Delta K$

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

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

B (5). A spring under a compression of x has a potential energy Vo. When the compression is doubled to $2x$, the potential energy stored in the spring is

A) $8Vo$
B) $4Vo$
C) $2Vo$
D) Vo
E) 0

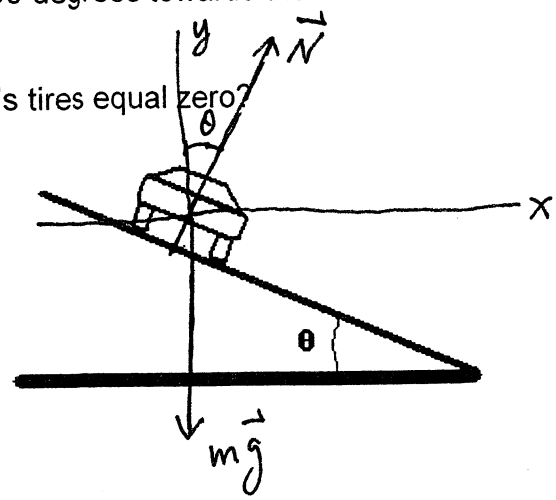
$U = \frac{1}{2} k x^2$

Part II Full solution questions, **SHOW ALL WORK FOR FULL MARKS !**

(6). A race car undergoes uniform circular motion around a banked race track with a radius of 200m. The track is banked at an angle of 30 degrees towards the centre of the track is indicated below.

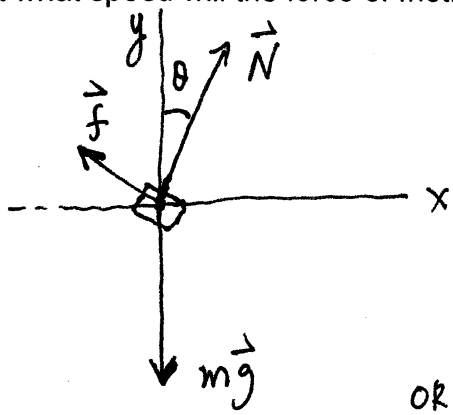
(a) Draw a free-body diagram of the car.

(b) At what speed will the force of friction on the car's tires equal zero?

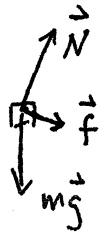


FBD:

(2) (a).



OR:



(b). $f = 0$.

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

(1) – x-comp.: $N\sin\theta = m\frac{v^2}{R}$ ①

(1) – y-comp: $N\cos\theta - mg = 0$. ②

Solve for v: ②: $N = \frac{mg}{\cos\theta}$.

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

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

(1) —— $v = \sqrt{Rg\tan\theta}$

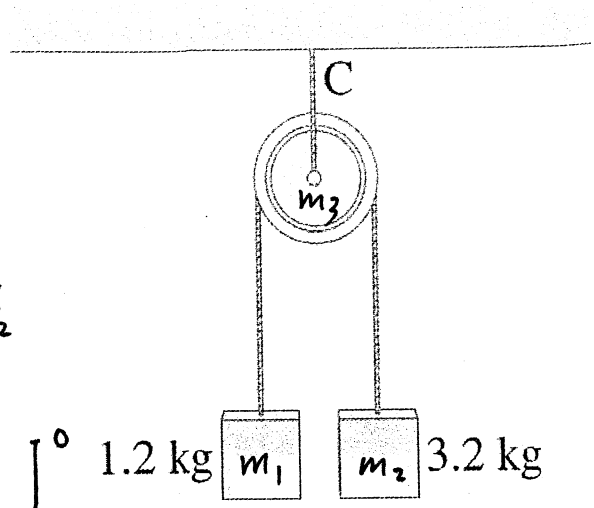
$$= \sqrt{200 \times 9.8 \times \tan 30^\circ}$$

$$= 33.6 \text{ m/s}$$

(7) Suppose the pulley in the figure has a mass of 1.0kg and is suspended by a cord C. Ignore the mass of the cords.

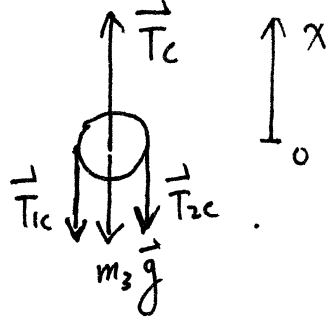
(a) Draw a free-body diagram for the pulley and for each of the two masses.

(b) Determine the tension in cord C after the masses are released and before one hits the ground.

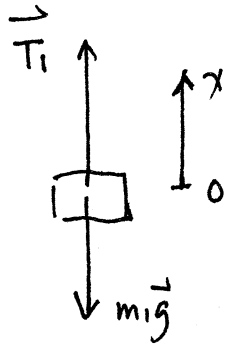


(a). Pulley:

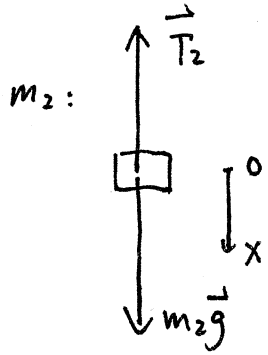
m_3:



m_1:



m_2:



(b). $\vec{F} = m\vec{a}$: (x-comp. only).

m_1: $T_1 - m_1 g = m_1 a$.

m_2: $m_2 g - T_2 = m_2 a$

m_3: $T_C - T_{1C} - T_{2C} - m_3 g = 0$.

Ignore cable mass: $T_1 = T_2 = T_{1C} = T_{2C} = T$

Solve for T_C:

$$a = \frac{m_2 - m_1}{m_1 + m_2} g = 4.45\ m/s^2$$

$$T = m_1(a+g) = 17.1\ N$$

$$T_C = m_3 g + 2T = 44\ N.$$

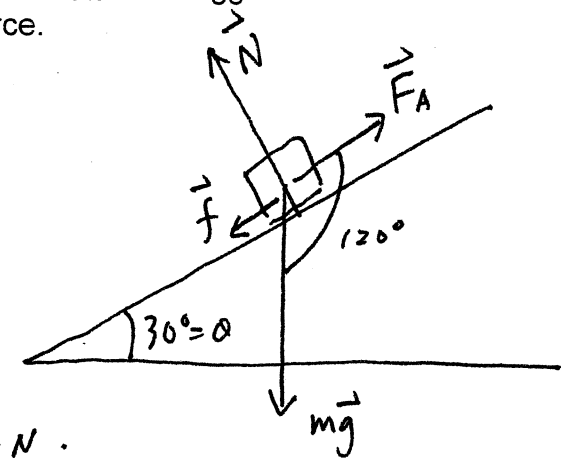
Note: Here we do not consider the rotational effects of the pulley. (assuming the radius of pulley small).

(8) You drag a 10 kg suitcase up a 30° ramp at constant velocity of 0.10m/s. The coefficient of kinetic friction is μ_k=0.25. The total distance dragged is 2.0 m.

(a) Find the work done by the gravitational force.

(b) Find the work done by the frictional force.

(c) Find the work done by the normal force.



(a). $W_g = mg \cdot d \cdot \cos 120°$

$= 10 \times 9.8 \times 2.0 \times \cos 120°$

$= -98$ J

(b). $W_f = -\mu_K \cdot N \cdot d$ $\quad mg\cos\theta = N$.

$= -\mu_K \underline{mg\cos\theta} \cdot d$

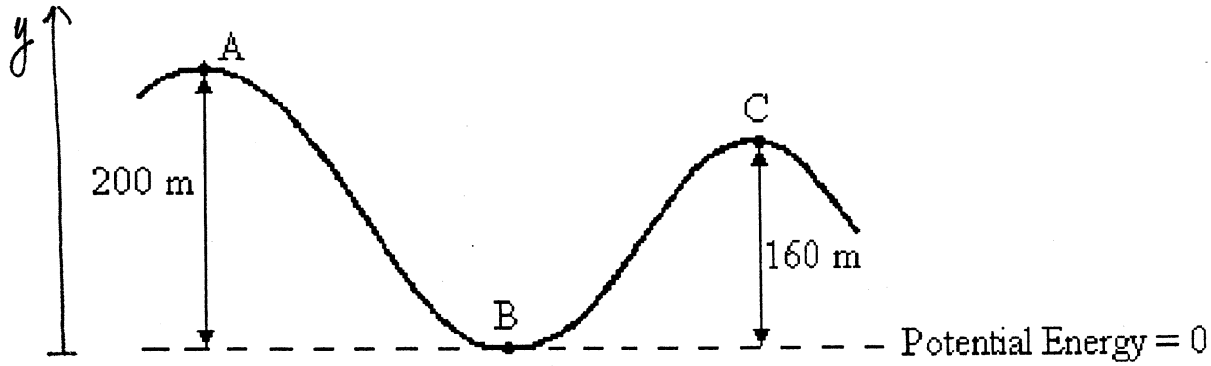
$= -0.25 \times 10 \times 9.8 \times \cos 30° \times 2$

$= -42.4$ J

(c). $W_N = 0$ (Since $\vec{N} \perp \vec{d}$)

(9) A roller coaster of mass 100.0kg is moving with a speed of 20.0m/s at position A as shown in the figure below. The vertical height at position A above ground level is 200m. Define the potential energy at the ground level as zero. Neglect friction.

(a) What is the total energy of the roller coaster at point A?
(b) What is the total energy of the roller coaster at point B?
(c) What is the speed of the roller coaster at point B?
(d) What is the speed of the roller coaster at point C?



Since $W_{nc} = 0$, Mechanical Energy is conserved ... i.e. $E = \text{const}$.

(a). $E_A = mg y_A + \frac{1}{2} m V_A^2 = 100 \times 9.8 \times 200 + \frac{1}{2} \times 100 \times 20^2 = 216{,}000\ J$.

(b). $E_B = E_A = 216000\ J$.

(c). $U_B = 0$. $\frac{1}{2} m V_B^2 = E_B$, $V_B = \sqrt{\frac{2E_B}{m}} = \sqrt{\frac{2 \times 216000}{100}} = 65.7\ m/s$

(d). $E_A = E_C = \frac{1}{2} m V_C^2 + mg y_C$

$$V_C = \sqrt{\frac{2(E_A - mgy_C)}{m}} = \sqrt{\frac{2(216000 - 100 \times 9.8 \times 160)}{100}} = 34.4\ m/s$$

OR: $\frac{1}{2} m V_B^2 = \frac{1}{2} m V_C^2 + mg y_C$

$$\frac{1}{2} V_C^2 = \frac{1}{2} V_B^2 - g y_C$$

$$V_C = \sqrt{V_B^2 - 2g y_C} = 34.4\ m/s.$$

PHYS 101 Midterm Examination #1 (version B)

Feb. 13, 2009

Time: 50 minutes

Last Name : _____

First Name : _____

Student No. : _____

Computing ID : _____

	score	*maximum*
Multiple Choice		***5***
Written # 1		***5***
Written # 2		***5***
Written # 3		***5***
Written # 4		***5***
Total		***25***

CDEAB

Part I (Multiple choice questions. 1 mark each. Please circle ***one*** answer for each question).

(1) An object is moving at a constant velocity. Which of the following statements must be true?

(A) A constant force is being applied in the direction of motion.
(B) There is no frictional force acting on the object.
(C) The net force acting on the object is zero.
(D) There are no forces acting on the object.
(E) The net force acting on the object depends on the magnitude of the velocity.

(2) An object is in a uniform circular motion. Which of the following statements must be true?

A) A net force pointing along the direction of motion is acting on the object.
B) The net force acting on the object is zero.
C) The velocity of the object is constant.
D) A net force pointing towards the center of the circle acts on the object.
E) The acceleration of the object is zero.

(3) When a parachutist jumps from an airplane, he eventually reaches a constant speed, called the terminal velocity. This means that

A) the acceleration is equal to g.
B) the force of air resistance is equal to zero.
C) the effect of gravity has died down.
D) the effect of gravity increases as he becomes closer to the ground.
E) the magnitude of drag force is equal to the weight of the parachutist.

(4) 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) 600 N
B) 667 N
C) 60 N
D) 3 N
E) 0.15 N

$W = \Delta K$

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

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

(5). A spring under a compression of x has a potential energy Vo. When the compression is doubled to $2x$, the potential energy stored in the spring is

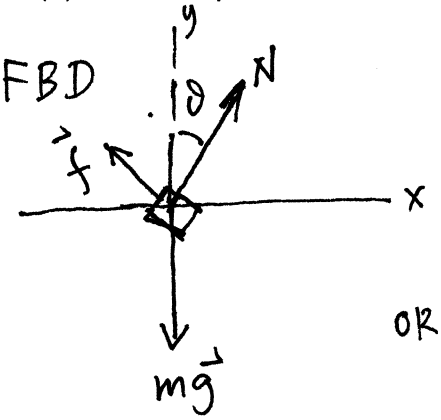
A) $8Vo$
B) $4Vo$
C) $2Vo$
D) Vo
E) 0

$U = \frac{1}{2} k x^2$

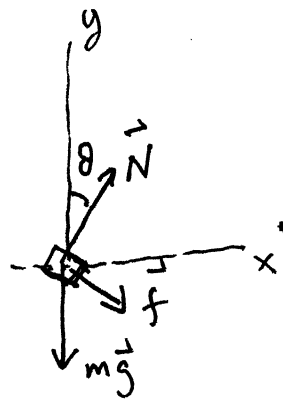
Part II Full solution questions, **SHOW ALL WORK FOR FULL MARKS !**

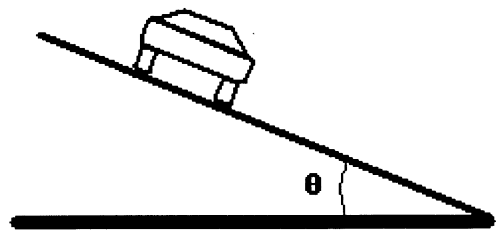
(6). A race car undergoes uniform circular motion around a banked race track with a radius of 100m. The track is banked at an angle of 30 degrees towards the centre of the track is indicated below.
(a) Draw a free-body diagram of the car.
(b) At what speed will the force of friction on the car's tires equal zero?

(a) (2) FBD



OR.





(b). $f = 0$.

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

y-comp: $N\cos\theta - mg = 0$. ② — (1)

Solve for v: ②: $N = \frac{mg}{\cos\theta}$

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

$g\tan\theta = \frac{v^2}{R}$.

$v = \sqrt{Rg\tan\theta}$ — (1)

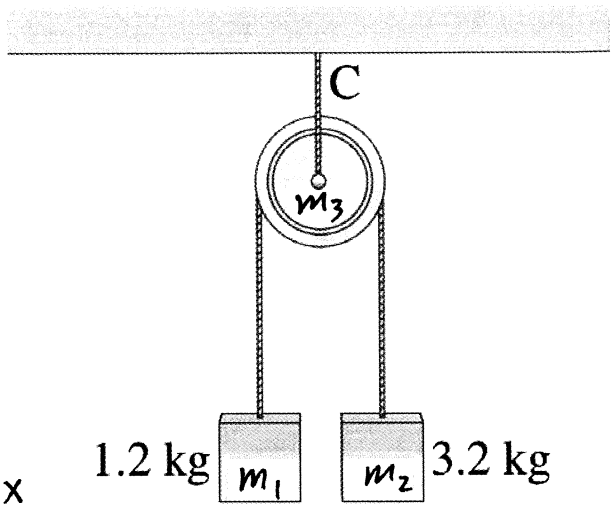
$= \sqrt{100 \times 9.8 \times \tan 30^\circ}$

$= 23.8$ m/s

(7) Suppose the pulley in the figure has a mass of 2.0kg and is suspended by a cord C. Ignore the mass of the cords.

(a) Draw a free-body diagram for the pulley and for each of the two masses.

(b) Determine the tension in cord C after the masses are released and before one hits the ground.



(a). Pulley: m_3: $\vec{T}_C$, $\vec{T}_{1C}$, $\vec{T}_{2C}$, $m_3\vec{g}$; x, 0

m_1: $\vec{T}_1$, $m_1\vec{g}$; x, 0

m_2: $\vec{T}_2$, $m_2\vec{g}$; x

(b). $\vec{F} = m\vec{a}$ (x-comp. only).

m_1 : $T_1 - m_1 g = m_1 a$

m_2 : $m_2 g - T_2 = m_2 a$

m_3 : $T_C - T_{1C} - T_{2C} - m_3 g = 0$.

Ignore mass of cables:

$T_1 = T_2 = T_{1C} = T_{2C} = T$

Solve for T_C: $a = \frac{m_2 - m_1}{m_1 + m_2} g = 4.45\ m/s^2$

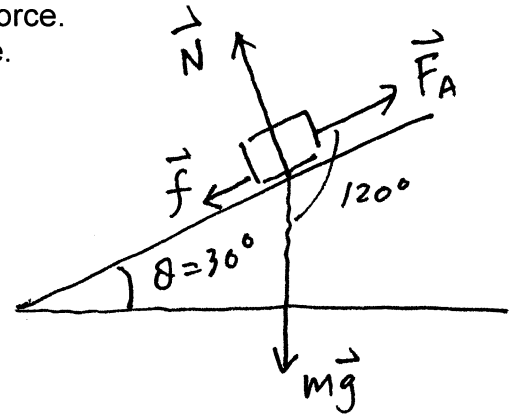
$T = m_1(a+g) = 17.1\ N$

$T_C = m_3 g + 2T = 2 \times 9.8 + 2 \times 17.1 = 53.8\ N$.

Note: Here we ignore the rotational effect of the pulley (assuming the radius is small).

(8) You drag a 40 kg suitcase up a 30° ramp at constant velocity of 0.10m/s. The coefficient of kinetic friction is μ_k=0.25. The total distance dragged is 2.0 m.

(2) (a) Find the work done by the gravitational force.
(2) (b) Find the work done by the frictional force.
(1) (c) Find the work done by the normal force.



(a). $W_g = mg \cdot d \cdot \cos 120°$

$= 40 \times 9.8 \times 2 \times \cos 120°$

$= -392$ J

(b). $W_f = -\mu_K N \cdot d$. $N = mg\cos\theta$

$= -\mu_K mg\cos\theta \cdot d$

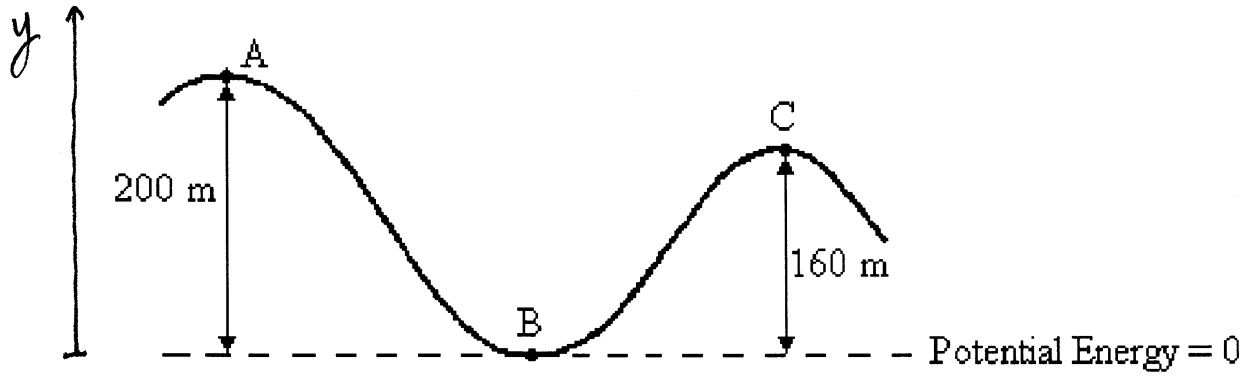
$= -0.25 \times 40 \times 9.8 \times \cos 30° \times 2$.

$= -170$ J .

(c). $W_N = 0$. (Since $\vec{N} \perp \vec{d}$)

(9) A roller coaster of mass 80.0kg is moving with a speed of 20.0m/s at position A as shown in the figure below. The vertical height at position A above ground level is 200m. Define the potential energy at the ground level as zero. Neglect friction.

(a) What is the total energy of the roller coaster at point A?
(b) What is the total energy of the roller coaster at point B?
(c) What is the speed of the roller coaster at point B?
(d) What is the speed of the roller coaster at point C?



(1) Since $W_{nc} = 0$, Mechanical energy is conserved : $E = \text{Const.}$

(1) (a). $E_A = mgy_A + \frac{1}{2}mv_A^2 = 80 \times 9.8 \times 200 + \frac{1}{2} \times 80 \times 20^2 = 172800\ J$

(1) (b). $E_B = E_A = 172800\ J$.

(1) (c). $U_B = 0$, $\frac{1}{2}mv_B^2 = E_B$, $v_B = \sqrt{\frac{2E_B}{m}} = \sqrt{\frac{2 \times 172800}{80}} = 65.7\ m/s$

(1) (d). $E_A = E_C = \frac{1}{2}mv_C^2 + mgy_C$.

$$v_C = \sqrt{\frac{2(E_A - mgy_C)}{m}} = \sqrt{\frac{2(172800 - 80 \times 9.8 \times 160)}{80}} = 34.4\ m/s$$

OR. $\frac{1}{2}mv_B^2 = \frac{1}{2}mv_C^2 + mgy_C$

$$\frac{1}{2}v_C^2 = \frac{1}{2}v_B^2 - gy_C$$

$$v_C = \sqrt{v_B^2 - 2gy_C} = 34.4\ m/s.$$