Exam 2   Phys 105   Fall 2003

Name _____Solution_____ Section _____

The exam is closed book and closed notes.

Part I: There are 10 multiple choice Questions.

Make sure you put your name, section, and ID number on the SCANTRON form. The answers for the

multiple choice Questions are to be placed on the SCANTRON form provided. Use a Number 2 pencil to

fill in answers on the SCANTRON form. Make sure you give only one (1) answer to each question. **If**

you erase an answer on the SCANTRON form, make sure all traces are removed.

Parts II : Workout problems. Show ALL your work. Correct answers with unsubstantiated work will

receive **ZERO CREDIT**.

Part I (30 points)

Part I (3 points each) Put the answers to these 10 questions on your SCANTRON sheet. Your answer should
be **CLOSEST TO THE GIVEN ANSWERS**.

1. A person pulls a block across a rough horizontal surface at a constant speed by applying a
   force F.   The arrows in the diagram below correctly indicate the directions, but not
   necessarily the magnitudes of the various forces on the block.   Which of the following
   relations among the force magnitudes W, f_k, N, and F must be true?

   A) $F=f_k$ and $N=W$

   B) $F=f_k$ and $N>W$

   C) $F>f_k$ and $N<W$ ⟵ (circled)

   D) $F<f_k$ and $N=W$

   $$F \cdot \cos\theta \geq f_k \implies F > f_k$$
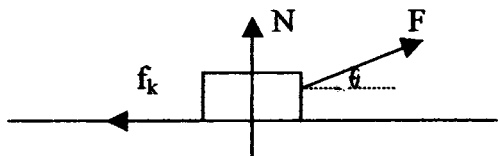
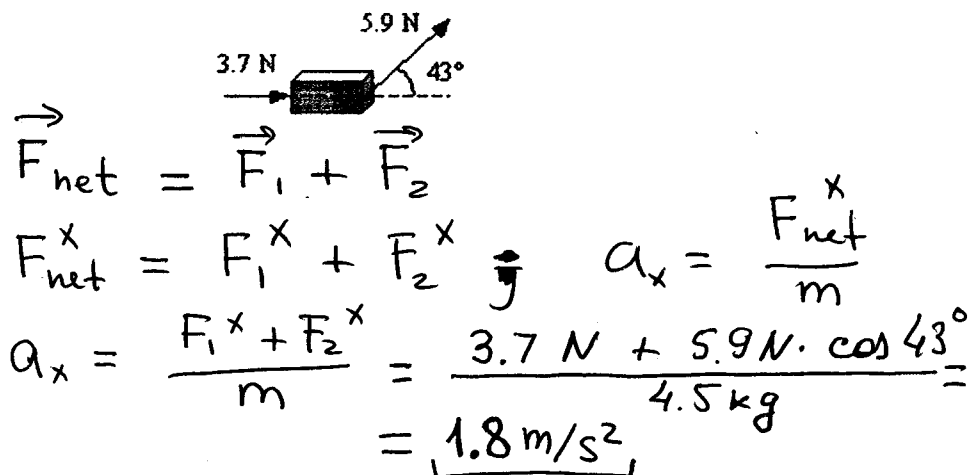
   $$N + F \cdot \sin\theta = W \implies W > N$$

   $$\implies C''$$

2. A heavy ball is suspended as shown. The upper and lower strings are identical. A quick jerk on the lower
   string will break that string, but a slow pull on the lower string will break the upper string. The first result
   occurs because:

   A) the force is too small to move the ball

   B) action and reaction

   C) the ball has inertia   (circled)

   D) air friction holds the ball back

   E) the ball has too much energy

A
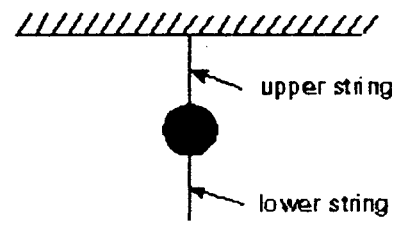
3. Two forces act on a 4.5-kg block resting on a frictionless, horizontal surface as shown. What is the magnitude of the horizontal acceleration of the block?

5.9 N

3.7 N   43°

A) 1.8 m/s²

B) 1.2 m/s²

C) 0.82 m/s²

D) 3.2 m/s²

E) 8.9 m/s²

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2$$

$$F_{net}^x = F_1^x + F_2^x \;\; ; \;\; a_x = \frac{F_{net}^x}{m}$$

$$a_x = \frac{F_1^x + F_2^x}{m} = \frac{3.7\,N + 5.9\,N \cdot \cos 43°}{4.5\,kg} =$$

$$= 1.8\,m/s²$$

4. A 71-kg man stands on a bathroom scale in an elevator. What does the scale read if the elevator is ascending with an acceleration of 3.0 m/s²?

A) 140 N

B) 480 N

C) 690 N

D) 830 N

E) 910 N

Scale reads N (normal force) $\vec{a} \uparrow$ $\uparrow N$ $\downarrow mg$

F.B.D.: $ma = N - mg$

$N = m(a+g)$

$N = 71\,kg\,(9.8 + 3)\,m/s² = 71 \cdot 12.8\,(Newtons) =$

$= 910\,N$

5. A 2150-kg truck is traveling along a straight, level road at a constant speed of 55.0 km/h when the driver removes his foot from the accelerator. After 21.0 s, the truck's speed is 33.0 km/h. What is the magnitude of the average net force acting on the truck during the 21.0 s interval?

A) 2250 N

B) 626 N

C) 1890 N

D) 972 N

E) 229 N

$$V_0 = 55\,km/h = \frac{55}{3.6}\,m/s = 15.3\,m/s$$
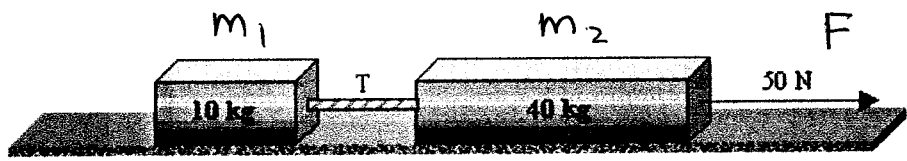
$$V = 33\,km/h = 9.2\,m/s$$

$$V^2 - V_0^2 = a \cdot 2 \cdot X$$

$$V = V_0 - a \cdot t$$

$$a = \frac{V_0 - V}{t} \;\; ; \;\; F = ma = m \cdot \frac{V_0 - V}{t}$$

$$F = 2150 \cdot \left(\frac{15.3 - 9.2}{21}\right) = 626\,N$$

6. A 10-kg block is connected to a 40-kg block as shown in the figure. The surface on which the blocks slide is frictionless. A force of 50 N pulls the blocks to the right. What is the magnitude of the tension **T** in the rope that connects the two blocks?

m_1 m_2 F

T   50 N

10 kg   40 kg

A) 0 N

B) 10 N

C) 20 N

D) 40 N

E) 50 N

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

$$T = a \cdot m_1 = m_1 \frac{F}{m_1 + m_2} = \frac{50\,N}{50\,kg} \cdot 10\,kg =$$

$$T = 10\,N$$

7. A 2.0-kg book is given an initial velocity of 4.9 m/s on a horizontal wooden surface and slides 2.5 meters before coming to rest. The coefficient of kinetic friction is most nearly:

A) 0.075

B) 0.18

C) 0.38

D) 0.49

N $\vec{V_0}$

f_k mg

$$f_k = N \cdot \mu_k \quad ; \quad N = mg$$

$$\mu = \frac{f_k}{mg}$$

$$f_k = ma \quad ; \qquad V^2 - V_0^2 = -2a \cdot X \Big\} \quad a = \frac{V_0^2}{2X}$$

$$V = \emptyset$$
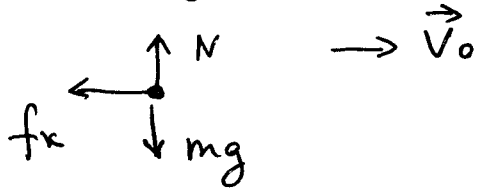
$$\mu = \frac{ma}{mg} = \frac{V_0^2}{2Xg} = 0.49$$

8. Block B, which has a mass of 100 kg, is raised from the Earth's surface by means of pulley system shown. If force F has a magnitude of 1200 N and friction is negligible, block B will move upward with a constant

A) velocity of about 2 m/s

B) velocity of about 12.0 m/s

C) acceleration of about 2 m/s²

D) acceleration of about 10.0 m/s²

x

T

B

F

mg
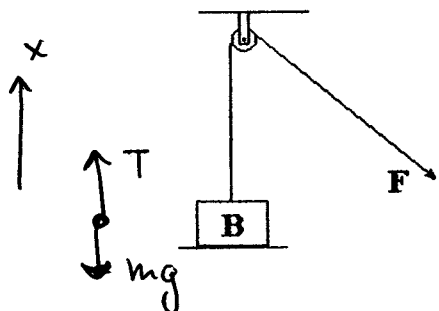
$$T = F \quad ; \quad T - mg = ma$$

$$mg = 980\,N \qquad ma = 1200\,N - 980\,N = 220\,N$$

$$a = \frac{220\,N}{100\,kg} = 2.2\,m/s^2 \ (up)$$

9. A roller coaster track has a hill with a circular curve of radius r = 25 m. What is the normal force on the 60-kg passenger when the roller coaster passes the hill at v = 12 m/s?
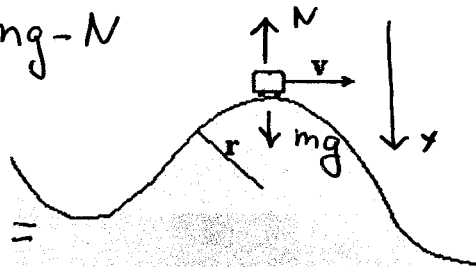
A) 242 N

B) 386 N

C) 588 N

D) 715 N

$$\underline{y}\colon \; ma = \frac{mv^2}{R} = mg - N$$

$$N = mg - \frac{mv^2}{R}$$

$$N = 60\left(9.8 - \frac{12 \cdot 12}{25}\right) =$$
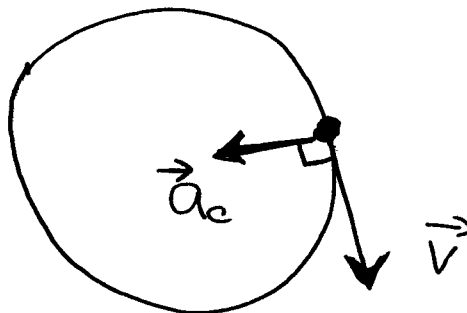
$$= \underline{242\,N}$$

10. A particle moves at constant speed in a circular path. The instantaneous velocity and instantaneous acceleration vectors are:

A) Both tangent to the circular path

B) Both perpendicular to the circular path

C) Perpendicular to each other

D) Opposite to each other

Part II : Workout problems.

WORKOUT PROBLEM #1 (10 points):

For the diagram shown, assume that the pulley is massless and frictionless, the

incline is frictionless and long, the string is massless, **m** = 5.0 kg and θ = 30°.

Starting from rest, the mass **m** moves uphill with a constant acceleration. The

magnitude of acceleration is a = 2.0 m/s².

a) Draw the free-body-diagram of each of the objects (m and M). Clearly
draw and label the axes of the coordinate system you are using for each
diagram.
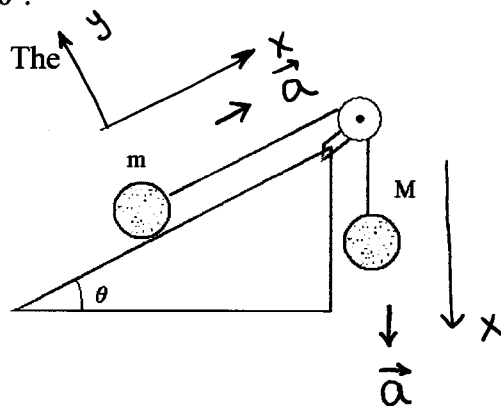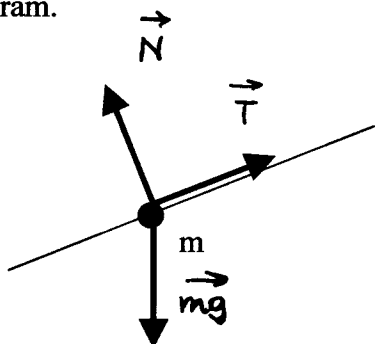
b) Write components of Newton's 2nd Law of Motion for each of the masses using symbols only (M,

m, θ, g, T, N)

$\boxed{m}$ $\underline{x:}$ $ma = T - mg\sin\theta$ $\boxed{M}$ $\underline{x:}$ $Ma = Mg - T$

$\underline{y:}$ $\emptyset = N - mg\cos\theta$

c) Solve the equations in part b using the data supplied and find the tension in the string **T** and

the mass **M**. $|\vec{a}|$ and $|\vec{T}|$ are the same for both m, M

$T = ma + mg\sin\theta$ $|$ $T = Mg - Ma$

$T = 5\,kg \cdot 2\,\frac{m}{s^2} + 5\,kg \cdot 9.8\,\frac{m}{s^2} \cdot \sin 30°$ $|$ $M = \dfrac{T}{g - a}$

$T = 10\,N + 24.5\,N \approx 35\,N$ $|$ $M = \dfrac{35}{(9.8 - 2)}\,kg$

T = $\underline{35}$ (N) $|$ M = $\underline{4.4}$ kg

d) What value of M would be consistent with the situation when both m and M are at rest ? $a = \emptyset$

$T' = mg \cdot \sin\theta$ $\Big\}$ $M' = m \cdot \sin\theta$ M = $\underline{2.5}$ kg

$T' = Mg$ $\Big\}$ $M' = 5\,kg / 2$

WORKOUT PROBLEM #2 (10 points):

A truck with the mass of $M = 5000$ kg is rounding a level curve at a speed of $v = 20$ m/s.

The coefficient of static friction between the road and the tires is $\mu_s = 0.41$

(a) Draw the free-body diagram for the moving truck

N

f_{st}

Mg
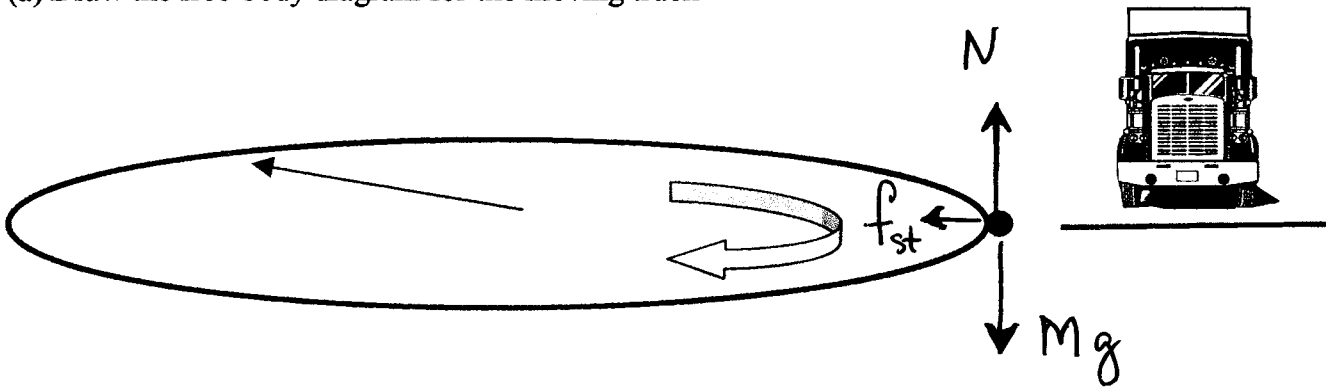
(b) What is the minimum radius R of the curve for which the truck can round the level curve

without skidding?

$$f_{st} = f_{st}^{max} = \mu_{st} \cdot N$$

$$N = Mg \implies f_{st}^{max} = \mu_{st} \cdot M \cdot g$$

R = __100__ m

$$f_{st} = \frac{Mv^2}{R} \implies \frac{Mv^2}{R} = \mu_{st} \cdot M \cdot g \implies R^{min} = \frac{v^2}{\mu \cdot g}$$

$$R^{min} = \frac{400}{0.41 \cdot 9.8} \ (m) = 100 \ m$$

(c) Will the answer for the minimum radius R change if the truck is loaded and its mass

increases by 50% ?

$$R^{min} = \frac{v^2}{\mu \cdot g} ;$$

R does not depend on M,

so it won't change

(d) If the curve is banked rather than flat, does the minimum radius at which the truck can safely

turn without skidding at $v = 20$m/s increase or decrease compared to the case of a flat curve?

Justify your answer using **new** free-body-diagram and a brief explanation.

If the curve is banked, then there is
an additional component of $N \cdot \sin\theta$
to the centripetal force.
Hence, the R^{min} will
decrease.

N

f_{st}

$N \cdot \sin\theta$

$$\frac{mv^2}{R} = f_{st} + N \cdot \sin\theta$$

$$R^{min} \approx \frac{v^2}{Mg + \tan\theta}$$