Physics 1303.001 **Fall 2011**

Exam 2 **Instructions**

All students at SMU are under the jurisdiction of the Honor Code, which you have already signed a pledge to uphold upon entering the University. For this particular exam, you may not give help to nor receive help from any other student. You are bound by the Honor Code to report any infractions to me or to the Honor Council.

Part I is multiple choice. Write your name and mark your responses both on the exam and on the Scantron form. Be sure to use a No. 2 pencil.

Part II consists of three free response problems. Show your work on the following pages to receive partial credit. Box final answers. Pen or pencil is fine. All exams are closed book. You may use one formula sheet written on both sides and a calculator. Cell phones, iPads, laptops, etc. must be switched off.

Part I (60 pts) Multiple Choice

Name: ______________________________ **Date:** _____________________

1. Figure 1a shows two horizontal forces that act on a block that is sliding to the right across a frictionless floor. Figure 1b shows three plots of the block's kinetic energy K versus time t. Which of the plots best corresponds to: $F_1 > F_2$?

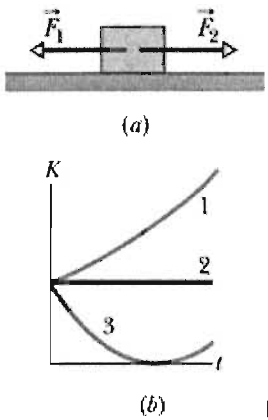


Figure 1

$F_1 > F_2 \Rightarrow F_N$ is to the left, opposite the blocks, motion

The block begins w/ $K = \frac{1}{2}mv_0^2$ and as it decelerates to $v=0$, K becomes zero. The block then accelerates to the right w/ $v > 0$.

$\therefore$ plot3 is appropriate

A) plot 1

B) plot 2

C) plot 3

2. Is positive or negative work done by a constant force $\vec{F}$ on a particle during a straight-line displacement $\vec{d}$ if

the angle between $\vec{F}$ and $\vec{d}$ is 100°.

$W = \vec{F} \cdot \vec{d} = Fd\cos\theta$

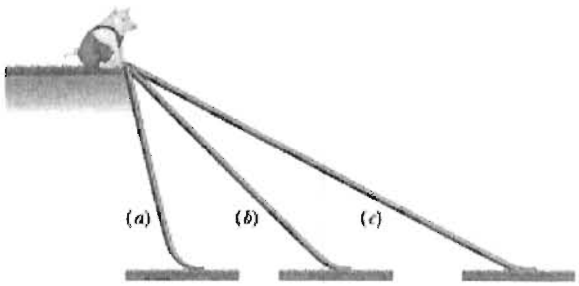
$W < 0 \therefore \cos 100° < 0$

A) positive

B) negative

C) zero

3. In the figure below, a greased pig has a choice of three frictionless slides along which to slide to the ground. Rank the slides according to how much work the gravitational force does on the pig during the descent, greatest first.



Same vertical displacement

∴ all paths are equal

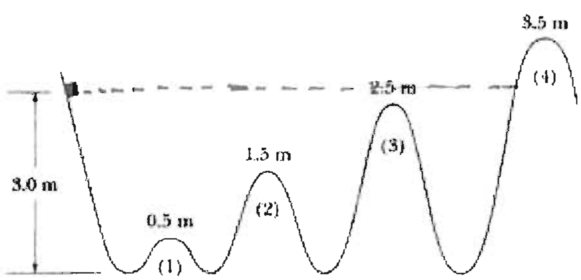
A) $c > b > a$

B) $a = b = c$

C) $a > b > c$

4. In the figure below, a small, initially stationary block is released on a frictionless ramp at a height of 3.0 m. Hill heights along the ramp are as shown. The hills have identical circular tops, and the block does not fly off any hill.

E_{mec}



$E_{mec} = K + U$

release from rest @ $h = 3\,m$

$E_{mec} = mg(3m) \Rightarrow$ hill (4) is too high

Which hill is the first the block cannot cross?

A) Hill 2

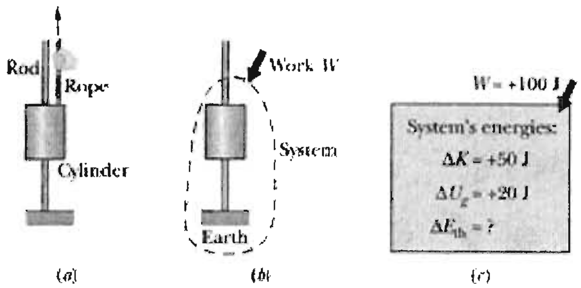
B) Hill 4

C) Hill 1

D) Hill 3

5. In Fig. *a*, you pull upward on a rope that is attached to a cylinder on a vertical rod. Because the cylinder fits tightly on the rod, the cylinder slides along the rod with considerable friction. Your force does work ($W = +100$ J) on the cylinder–rod–Earth system (Fig. *b*). An "energy statement" for the system is shown in Fig. *c*: the kinetic energy K increases by 50 J, and the gravitational potential energy U_g increases by 20 J.

$W = \Delta E$



$W - \Delta K - \Delta U_g - \Delta E_{th} = 0$

$100J - 50J - 20J = \Delta E_{th}$

$\Delta E_{th} = 30J$

The only other change in energy within the system is for the thermal energy E_{th}. What is the change ΔE_{th}?

A) 70 J

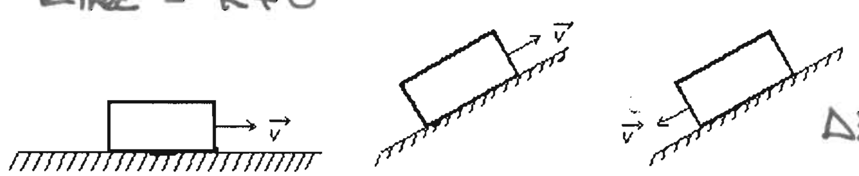
B) 30 J

C) 170 J

D) 130 J

6. Three identical blocks move either on a horizontal surface, up a plane, or down a plane, as shown below. They all start with the same speed and continue to move until brought to rest by friction. Rank the three situations according to the mechanical energy dissipated by friction, least to greatest.

$E_{mec} = K + U$



(1) (2) (3)

$\Delta E_{th} = k + mgh$

$\Delta E_{th} = K$ $\Delta E_{th} = K - mgh$

A) 2, 1, 3

B) 3, 2, 1

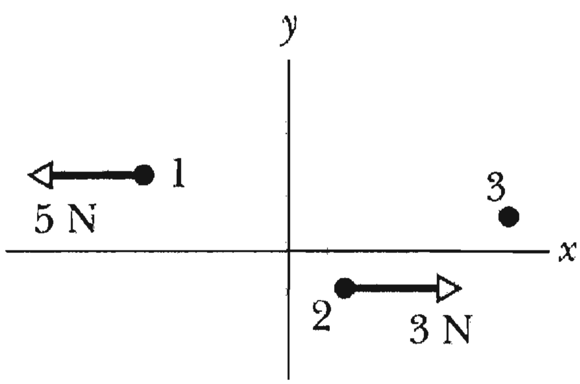
C) The same for all cases

D) 1, 2, 3

E) 1, then 2 and 3 tie

7. The figure below shows an overhead view of three identical particles on which external forces act. The magnitudes and directions of the forces on two of the particles are indicated. What are the magnitude and direction of the force acting on the third particle if the center of mass of the three-particle system is accelerating rightward?

$\Rightarrow F_N = M a_{com} > 0$



$-5N + 3N + F_3 > 0$

$F_3 > 2N$

$\oplus$ is to right

A) More than 2 N leftward

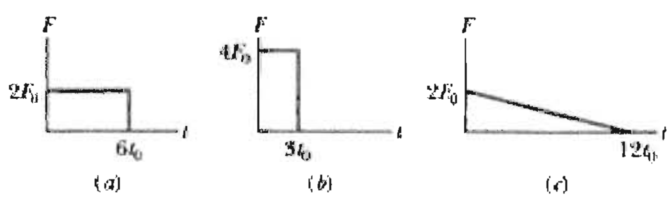
B) Exactly 2 N leftward

C) Between 2 N leftward and 2 N rightward

D) Exactly 2 N rightward

E) More than 2 N rightward

8. Figure 9-26 shows graphs of force magnitude versus time for a body involved in a collision. Rank the graphs according to the magnitude of the impulse on the body, greatest first.



$J = \int F\,dt$

= area under curve

$J_a = J_b = J_c = 12 F_0 t_0$

A) $c > a > b$

B) $c > b > a$

C) $a = b = c$

D) $b = a > c$

E) $c > b = a$

Part I (60 pts) Multiple Choice

9. The center of mass of a uniform disk of radius R is located:

A) on the rim

B) a distance $R/2$ from the center

C) a distance $R/3$ from the center

D) a distance $2R/3$ from the center

E) at the center

10. If the total momentum of a system is changing:

A) particles of the system must be exerting forces on each other

B) the system must be under the influence of gravity

C) the center of mass must have constant velocity

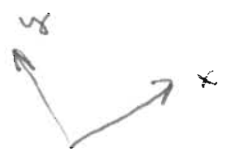
D) a net external force must be acting on the system

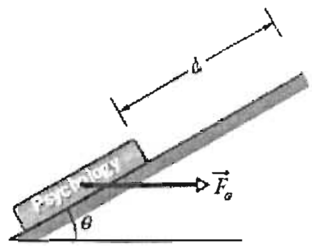
E) none of the above

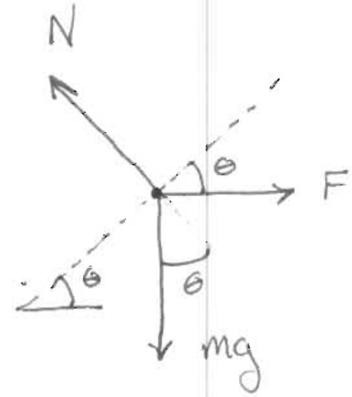
$\vec{F}_N = \frac{d\vec{P}}{dt} \neq 0$

$\Rightarrow \vec{F}_N \neq 0$

11.) In the figure, a horizontal force $\vec{F}$ of magnitude 20.0 N is applied to a 3.00 kg book as the book slides a distance d = 0.500 m up a frictionless ramp at angle θ = 30.0°. The book begins with zero kinetic energy. What is its speed at the end of the displacement?







F = ma + Kinematics

y: $N - F\sin\theta - mg\cos\theta = ma_y = 0$

x: $F\cos\theta - mg\sin\theta = ma_x \Rightarrow a_x = \frac{F}{m}\cos\theta - g\sin\theta$

$$v^2 = v_0^2 + 2a_x(x - x_0) = 0 + 2d\left(\frac{F}{m}\cos\theta - g\sin\theta\right)$$

$$v = \sqrt{2gd\left(\frac{F}{mg}\cos\theta - \sin\theta\right)}$$

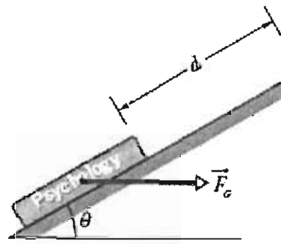
$$v = \sqrt{2(9.80)\frac{1}{2}\left(\frac{20.0}{3(9.80)}\cos 30^\circ - \sin 30^\circ\right)}$$

$$= \sqrt{9.8\left[\left(\frac{20.0}{3\times 9.8}\right)(0.866) - \frac{1}{2}\right]} = 0.9345$$

$$\boxed{v = 0.935\ \frac{m}{s}}$$

Part II (40 pts) Free Response

11.) In the figure, a horizontal force $\vec{F}$ of magnitude 20.0 N is applied to a 3.00 kg book as the book slides a distance d = 0.500 m up a frictionless ramp at angle θ = 30.0°. The book begins with zero kinetic energy. What is its speed at the end of the displacement?



$$\underline{W_N = \Delta K}$$

$$W_N = W_F + W_g$$

$$= Fd\cos\theta - mgd\sin\theta = \Delta K = \frac{1}{2}mv^2$$

$$\frac{2}{m}\left(\frac{Fg\,d}{g}\cos\theta - mgd\sin\theta\right) = v^2$$

$$v = \sqrt{2gd\left(\frac{F}{mg}\cos\theta - \sin\theta\right)}$$

$\underline{W_F = \Delta E_{mec.}}$ Isolated system w/ External Force F

$W_F = \Delta K + \Delta U$ $\quad W_F = Fd\cos\theta$ $\quad \Delta K = \frac{1}{2}mv^2$ $\quad \Delta U = mgd\sin\theta$

$$\Rightarrow \quad Fd\cos\theta = \frac{1}{2}mv^2 + mgd\sin\theta$$

$$\Rightarrow \quad \boxed{v = \sqrt{2gd\left(\frac{F}{mg}\cos\theta - \sin\theta\right)}}$$

12.) During spring semester at MIT, residents of the parallel buildings of the East Campus dorms battle one another with large catapults that are made with surgical hose mounted on a window frame. A balloon filled with dyed water is placed in a pouch attached to the hose, which is then stretched through the width of the room. Assume that the stretching of the hose obeys Hooke's law with a spring constant of 100. N/m. If the hose is stretched by 5.00 m and then released, how much work does the force from the hose do on the balloon in the pouch by the time the hose reaches its relaxed length?

$F = -kx$ $\quad k = 100.\ N/m$

$\Delta x = 5.00\ m$

$W = -\Delta U_s$

$\Delta U_s = \int kx\,dx = \frac{1}{2}kx^2 \Big|_5^0 = -\frac{1}{2}k(5.00)^2$

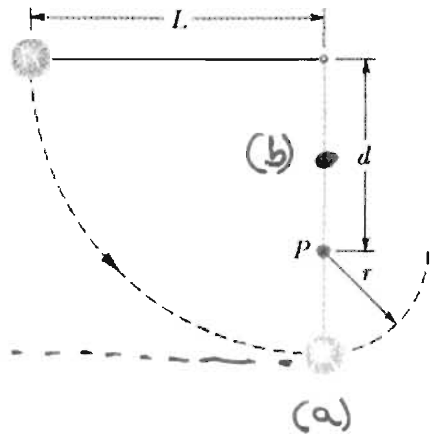
$= -\frac{1}{2}kx^2$

$W = \frac{1}{2}kx^2 = \frac{1}{2}(100.\ \frac{N}{m})(5.00\ m)^2$

$$\boxed{W = 1.25\ kJ}$$

13.) The string in figure below is L = 120. cm long, has a ball attached to one end, and is fixed at its other end. The distance d from the fixed end to a fixed peg at point P is 75.0 cm. When the initially stationary ball is released with the string horizontal as shown, it will swing along the dashed arc. What is its speed when it reaches (a) its lowest point and (b) its highest point after the string catches on the peg?

$E_{me} = mgL$



Choose zero of Pot. here

$r = L - d$

$= 120 - 75.0$ cm

$\boxed{r = 45.0 \text{ cm}}$

v @ a $\quad E_{mec} = \frac{1}{2}mv_a^2 = mgL \quad \Rightarrow \quad \boxed{v_a = \sqrt{2gL}}$

$\boxed{v_a = 4.85 \frac{m}{s}}$

v @ b $\quad E_{mec} = \frac{1}{2}\cancel{m}v_b^2 + \cancel{m}g(2r) = \cancel{m}gL$

$v_b^2 = 2gL - 2g(2r)$

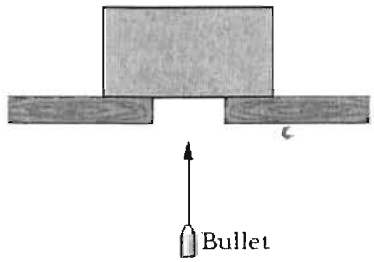
$v_b^2 = 2g(L - 2r)$

$\boxed{v_b = \sqrt{2g(L-2r)}}$

$\boxed{v_b = 2.42 \frac{m}{s}}$

Part II (40 pts) Free Response

14.) In the figure below, a bullet with mass m1 moving directly upward with speed v1i strikes and passes through the center of mass of a block with mass m2 which is initially at rest. The bullet emerges from the block moving directly upward and has slowed to a speed v1f. To what maximum height does the block then rise above its initial position? State your answer in terms of the given variables (use g where applicable).



Collision is inelastic but Momentum is Conserved

$$m_1 v_{1i} = m_1 v_{1f} + m_2 v_{2f}$$

$$\boxed{v_{2f} = \frac{m_1 (v_{1i} - v_{1f})}{m_2}}$$

After collision, the block / Earth system is isolated, this means E_{mec} is conserved.

$$K_i + U_i = K_f + U_f \qquad \text{chose } U(0) = 0$$

$$\frac{1}{2} \cancel{m_2} v_{2f}^2 = \cancel{m_2} g h \qquad \boxed{h = \frac{v_{2f}^2}{2g}}$$

$$\boxed{h = \frac{m_1^2 (v_{1i} - v_{1f})^2}{m_2^2 \cdot 2g}}$$