A

Exam 3 Phys 105 **Fall 2004**

The exam is closed book and closed notes. A one-page equation sheet is allowed.

"On my honor, I pledge that I have not violated the provisions of the NJIT Student Honor Code." Signature_____

Print Name Solutions **Section** _____

Part I: There are 10 multiple choice Questions.

Make sure you put your name, section, and ID number on the SCANTRON form. . **Failure to do so will cost you two points.** 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)

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1. A mass of 5kg experiences a force that changes its speed from 1.0m/s to a final speed of 2.3m/s. What is the change in the kinetic energy of the mass?

   A) 13 J

   B) 2.5 J

   C) 49 J

   D) 11 J

   E) -11 J

$$\Delta K = K_f - K_0$$
$$= \frac{1}{2} m v_f^2 - \frac{1}{2} m v_0^2$$
$$= \frac{1}{2} m (v_f^2 - v_0^2) = \frac{1}{2}(5\,kg)\left[(2.3\,m/s)^2 - (1\,m/s)^2\right]$$

2. A car brakes as it approaches a stop sign. Its initial speed before braking is 10m/s. Its final speed is zero (car stops). The mass of the car is 500kg. What is the work done by the braking force on the car?

   A) -4.9×10^3 J

   B) 2.5×10^4 J

   C) -2.5×10^4 J

   D) 4.9×10^3 J

   E) Not enough information. The distance it takes to stop the car is required.

$$W_{net} = \Delta K$$
$$W_{Brake} = \Delta K$$
$$W_{Brake} = \frac{1}{2} m (v_f^2 - v_0^2)$$
$$= \frac{1}{2}(500\,kg)\left[0 - (10\,m/s)^2\right]$$

3. A cord is used to vertically lower a block of mass M=3.00 kg from a building to the ground at a constant downward acceleration. The work done by the cord's force (Tension T) on the block is -100 J. Assuming that the block is initially at rest, what is its final speed after it moves downward 10m?

A) 8.16 m/s

B) 11.4 m/s

C) 14.0 m/s

D) 16.2 m/s

E) 129 m/s

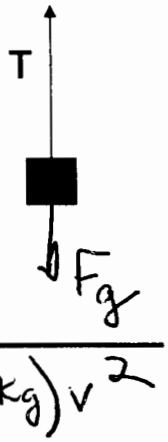
$W_{net} = \Delta K$

$W_T + W_g = \Delta K$

$-100J + mgd = \frac{1}{2}m(v^2 - v_0^2)$

$-100J + (3kg)(9.8 m/s^2)(10m) = \frac{1}{2}(3kg)v^2$

$129 m^2/s^2 = v^2$



$W_g = F_g d \cos\theta$

$\theta = 0°$

$W_g = F_g d$

$= mgd$

4. A force given by $\vec{F} = 210\,\hat{i} - 150\,\hat{j}$ (in Newtons). The force displaces a mass of 0.5kg by a vector (in meters) $\vec{d} = \frac{1}{7}\hat{i} + \frac{1}{5}\hat{j}$. The work done by the force $\vec{F}$ on the mass is

A) 60 J

B) -60 J

C) 21 J

D) 63.4 J

E) zero

$W_F = F_x x + F_y y$

$= (210N)(\frac{1}{7}m) + (-150N)(\frac{1}{5}m)$

$= 0$

5. The figure shows four forces (including gravity and the Normal force) acting on a block. The block of mass 3kg moves <u>to the right</u> a distance of 2.5m along the frictionless surface. The magnitude of F_1 is 10 Newtons. The magnitude of F_2 is 4 Newtons. The <u>net work</u> done on the block by <u>all four forces</u> is closest to

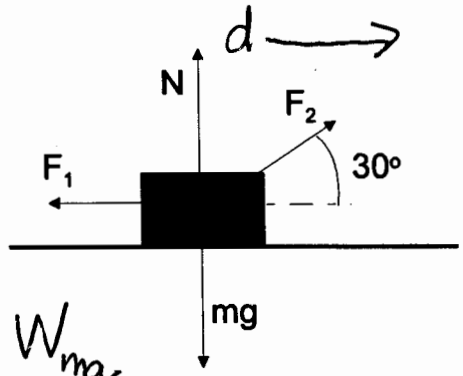
A) -16 J

B) -15 J

C) zero because the surface is frictionless

D) 15 J

E) 16 J



$W_{net} = W_{F_1} + W_{F_2} + W_N + W_{mg}$

$W_{net} = F_1 d \cos 180° + F_2 d \cos 30° + 0 + 0$

$W_{net} = -10N(2.5m) + (4N)(2.5m)(\cos 30°)$

$W_{net} = -16J$

6. Two objects, one of mass m and the other of mass $2m$, are dropped starting from rest from the top of a building. When they hit the ground:

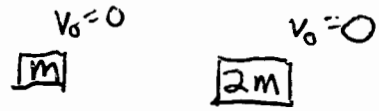
A) the heavier one will have one-fourth the kinetic energy of the lighter one.

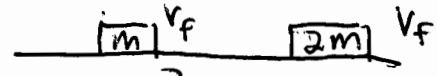
B) the heavier one will have four times the kinetic energy of the lighter one.

C) the heavier one will have twice the kinetic energy of the lighter one.

D) the heavier one will have half the kinetic energy of the lighter one.

E) both will have the same kinetic energy.





$K_f = \frac{1}{2} m V_f^2$ $\quad K_f = \frac{1}{2}(2m)(V_f^2)$

7. An ideal spring is used to fire a 15.0-g block horizontally across a frictionless table top. The spring has a spring constant of 20 N/m and is initially compressed by 7.0 cm. The speed of the block as it leaves the spring is:

A) 0

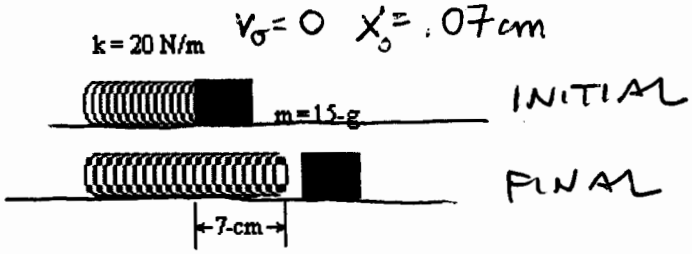
B) 1.9×10^{-3} m/s

C) 2.6×10^{-2} m/s

D) 0.39 m/s

E) 2.6 m/s

$W_{nc} = 0$



$K_i + U_{s_i} = K_f + U_{s_F}$

$V_f = ?$ $x_f = 0$

$0 + \frac{1}{2} k x^2 = \frac{1}{2} m V_f^2 + 0$

$\frac{k x^2}{m} = V_f^2$

$\frac{(20 N/m)(.07 m)^2}{.015 kg} = V_f^2$

8. At an amusement park, an 18-kg child slides from rest down a ramp into the pool below. The slide drops through a height of 2.2 m. The child starts at rest at the top of the slide. On the way down, the slide does a nonconservative work of – 373 J on the child. What is the child's speed at the bottom of the slide?

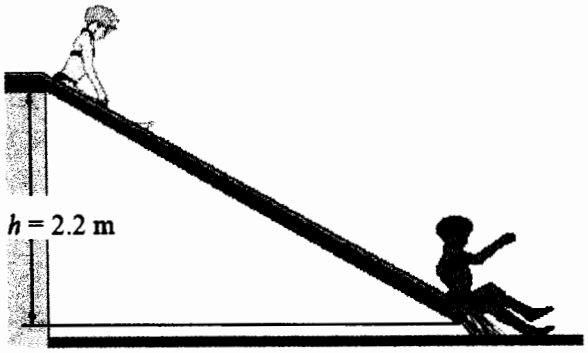
A) 6.2 m/s

B) 0.92 m/s

C) 6.6 m/s

D) 9.2 m/s

E) 1.3 m/s



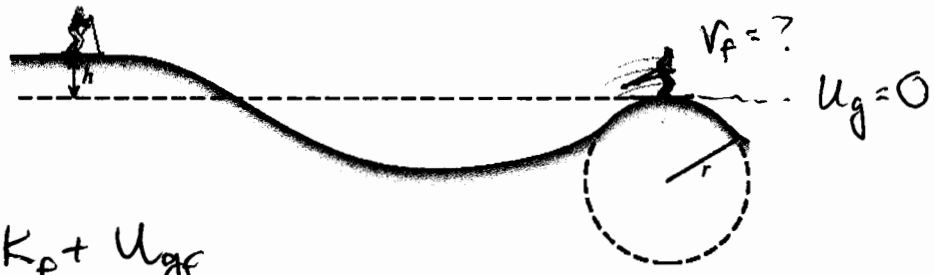
$W_{nc} = \Delta K + \Delta U_g$

$K_i + U_{g_i} + W_{nc} = K_f + U_{gf}$

$0 + mgh - 373 J = \frac{1}{2} m v^2 + 0$

$(18 kg)(9.8 m/s^2)(2.2 m) - 373 J = \frac{1}{2}(18 kg) v^2$

9. A skier starts from rest at the top of a hill. The skier coasts down the hill and up a second hill, as the drawing illustrates. The crest of the second hill is circular, with a radius of r = 23.0 m. Neglect friction and air resistance. What must be the height h of the first hill so that the skier just loses contact with the snow at the crest of the second hill?



A) 8 m

B) 42 m

C) 36 m

D) 12 m

E) 18 m

$W_{nc} = 0$

$K_i + U_{gi} = K_f + U_{gf}$

$0 + mgh = \frac{1}{2}mv^2 + 0$ need v_f to find h

$N = 0$ $F_g = \frac{mv^2}{r}$ $mg = \frac{mv^2}{r}$

$v^2 = gr$

$mgh = \frac{1}{2}m(gr)$

$h = \frac{23.0m}{2} = \frac{23.0m}{2}$

10. A 51-kg woman runs up a flight of stairs in 5.0 s. Her net upward displacement is 5.0 m. Approximately, what average power did the woman exert while she was running?

A) 5.0 kW

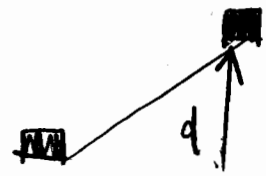
B) 1.0 kW

C) 0.75 kW

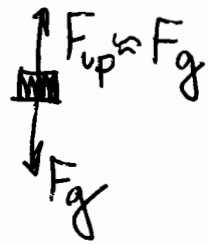
D) 0.50 kW

E) 0.25 kW

$P_{AVG} = \frac{W}{t}$



$P_{AVG} = \frac{F_g d \cos 0}{t}$



$P_{AVG} = \frac{mgd}{t}$

$= \frac{(51kg)(9.8 m/s^2)(5.0m)}{5.0s}$

$= 500 W$

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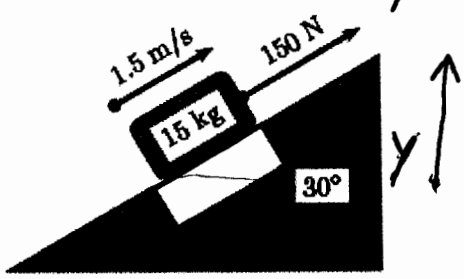
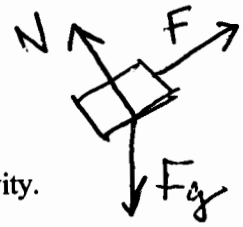
Part II: Workout problems (10 points each) **IN ORDER TO RECEIVE CREDIT, YOU MUST SHOW YOUR WORK. NO EXCEPTIONS.**

FOR BOTH WORKOUT PROBLEMS YOU ARE REQUIRED TO USE CONSERVATION OF ENERGY OR WORK-ENERGY THEOROM. DO NOT USE CONSTANT ACCELERATION FORMULAS. NO EXCEPTIONS.

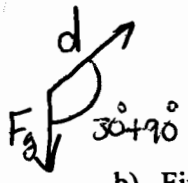
$y = d \sin 30^\circ$

1. A 15-kg crate is pulled by a 150-N force up a frictionless incline. The crate has an initial speed of 1.5 m/s and is pulled a distance of 7.5 m by the 150-N force.





a) Find the work done by the force of gravity.

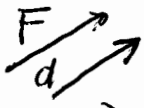


$W_g = mgd\cos\theta$ or $W_g = (mgy)\cos 180^\circ$

$= (15\,kg)(9.8\,m/s^2)(7.5\,m)(\cos 120^\circ)$ or $W_g = (15\,kg)(9.8\,m/s^2)(7.5\,m \sin 30^\circ)$

$= -551\,J \approx -550\,J$

b) Find the work on the crate done by the 150-N force.



$W_F = Fd\cos\theta$

$= (150\,N)(7.5\,m)(\cos 0^\circ) = 1125\,J \approx 1.1\times10^3\,J$

c) Find the work due to the normal force.

$W_N = Nd\cos\theta$

$= 0$ since $\theta = 90^\circ$

d) Using the **Work-Kinetic Energy theorem**, find the **Kinetic Energy** of the crate after it has moved 7.5m up the plane.

$W_{net} = \Delta K$

$W_g + W_F + \cancel{W_N}_{0} = K_F - K_0$

$W_g + W_F + \frac{1}{2}mv_0^2 = K_F$

$-551\,J + 1125\,J + 16.9\,J = K_F$

$590\,J = K_F$

e) Instead of the 150N force, a different force is used to move the crate up the incline at a constant speed. Using the **Work-Kinetic Energy theorem,** calculate the magnitude of this force.

$W_F + W_g = \Delta K$ v constant $\Rightarrow \Delta K = 0$

$Fd\cos 0^\circ + W_g = 0$

$F = \frac{-W_g}{d} = \frac{-(-551\,J)}{7.5\,m} = 73.5\,N \approx 74\,N$

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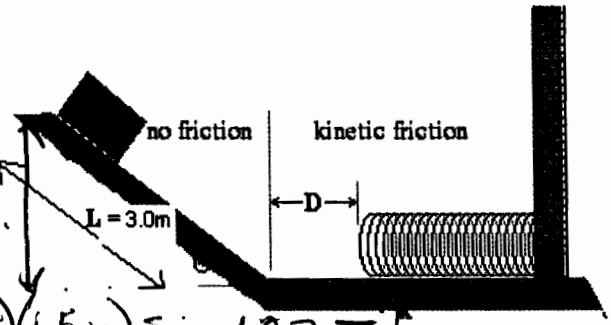
2. A 7-kg block slides down a frictionless, L=3 m long ramp at an angle $\Theta = 30^0$ starting from rest. At the end of the ramp it slides horizontally a distance D = 2 m along a path with friction (the coefficient of kinetic friction is $\mu_k = 0.15$).

(You ARE REQUIRED to use the principle of **Conservation of Energy** to solve parts b, d, and e)

a) Find the change in gravitational potential energy when the block slides down the ramp.



$h = 3.0m \sin 30^\circ =$

$\Delta U_g = U_{gf} - U_{gi}$

$= 0 - mgh = -(7kg)(9.8m/s^2)(1.5m) = -103J$

b) Determine the kinetic energy of the block at the bottom of the ramp.

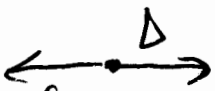
$W_{nc} = 0$

$\Delta K + \Delta U_g = 0$

$\Delta K = -\Delta U_g$

$K_f - K_i = -\Delta U_g$ $\quad K_f - 0 = -\Delta U_g$ $\quad K_f = 103J$

c) As the block slides along the horizontal surface, find the work done by friction force just before the block hits the spring.



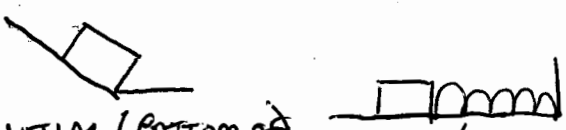
$f_k = \mu_k N$

$W_{f_k} = f_k \Delta \cos 180^\circ$

$= -\mu_k mg\Delta = -(0.15)(7kg)(9.8m/s^2)(2m) = -20.6$

$= -21J$

d) Find the kinetic energy of the block just before it hits the spring.



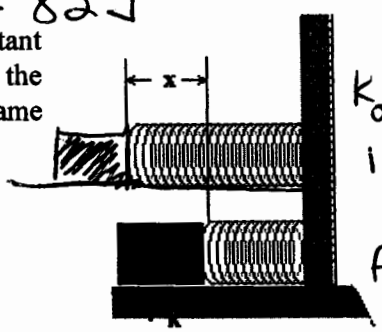
INITIAL (BOTTOM OF RAMP) FINAL (JUST BEFORE SPRING)

$K_i + U_{g_i} + U_{s_i} + W_{nc} = K_f + U_{g_f} + U_{s_f}$

$103J + 0 + 0 - 21J = K_f + 0 + 0$

$K_f = 82J$

e) The block will eventually be stopped by the spring which has a spring constant k = 200 N/m. Find the maximum distance *x* the spring is compressed at the instant when block stops. (Note that friction still acts on the block; use the same coefficient of friction $\mu_k = 0.15$ as the spring is being compressed).



$K_0 = 82J$

INITIAL

FINAL

$K_i + U_{g_i} + U_{s_i} + W_{nc} = K_f + U_{g_f} + U_{s_f}$

$82J + 0 + 0 - f_k x = 0 + 0 + \frac{1}{2}kx^2$

$82J - (\mu_k mg)x = \frac{1}{2}(200 N/m)x^2$

$82J - (10.3N)x = 100 N/m\, x^2$

Solve quadratic: $100x^2 + 10.3x - 82 = 0$ $\quad x = 0.86m$