Exam 3 Phys 105 **Fall 2003**

Name______________________________ **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.**

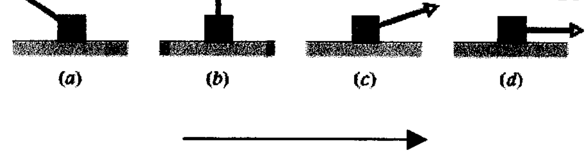
Parts II: Workout problems. Show ALL your work. Correct answers with unsubstantiated work will receive **ZERO CREDIT**.

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. The figure shows four situations in which a force acts on a box while the box slides rightward a distance *d* across a frictionless floor. The magnitudes of the forces are identical; their orientations are as shown. Rank the situations according to the work done by the force during the displacement of the box, from most positive to most negative.

$\cos\theta < 0$ $\cos\theta = 0$ $0 < \cos\theta < 1$ $\cos\theta = 1$



Direction of the box

A) d, c, b, a
B) d, a ,c ,b
C) c, d, b, a
D) a, b, c, d
E) b, c, d, a

$W = F \cdot d \cdot \cos\theta$; $F \cdot d$ is the same, while $\cos\theta$ is shown in the figure

The right answer is : d, c, b, a

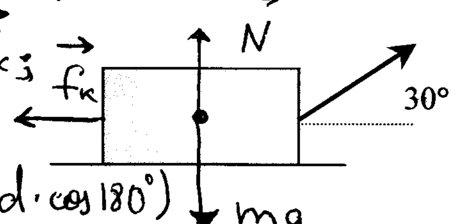
2. A 10-kg block is pulled from rest along a horizontal surface by a rope that exerts a 60-N force directed 30° above the horizontal as shown. The surface exerts a friction force of 20 N on the block. If the block is pulled through a distance 2.0 m, the total work done on the block by the net force is closest to

Since $F \cdot \sin 30 < mg$, the block is moving along the horizontal surface

A) 20 J
B) 42 J
C) 64 J
D) 74 J
E) 86 J

$W_{net} = \vec{F}_{net} \cdot \vec{d}$

$\vec{F}_{net} = \vec{F} + \vec{N} + m\vec{g} + \vec{f}_k$;



$\vec{F}_{net} \cdot \vec{d} =$

$= (F \cdot d \cdot \cos 30° + f_k \cdot d \cdot \cos 180°)$

$W_{net} = (60 \cdot 2 \cdot 0.86 - 20 \cdot 2)\,J = 64\,J$

3. A cord is used to vertically lower an initially stationary 10-kg block at a constant acceleration of 1.2 m/s^2. When the block has fallen a distance 5.0 m, the change in the gravitational potential energy of the block is:

A) +300 J

B) -300 J

C) +490 J

D) -490 J

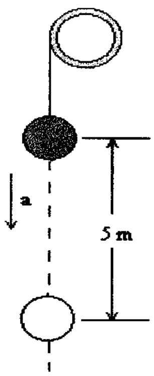
E) +960

$\Delta U = mg\Delta y$

Δy is negative

$\Delta U = -10 \cdot 9.8 \cdot 5 =$

$= \underline{-490\,J}$



Anothe way to get the same result:

$\Delta U = -W_g =$

$= -F_g \cdot d =$

$= -mg \cdot d =$

$= -10 \cdot 9.8 \cdot 5 = \boxed{-490\,J}$

4. A block initially at rest is allowed to slide down a frictionless ramp. The block attains a speed *v* at the bottom of the ramp. To achieve a speed 2*v* at the bottom, how many times as high must a new ramp be?

A) 1

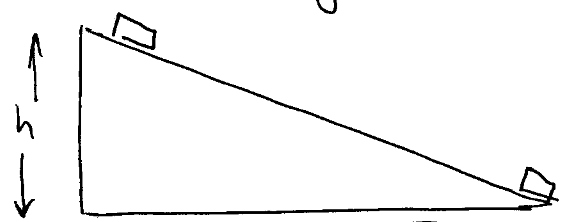
B) 2

C) 3

D) 4

E) 5

$E = U = mgh$



$E = \frac{mv^2}{2}$

$mgh = \frac{mv^2}{2}$

$V = \sqrt{2gh}$

$2V = \sqrt{2g \cdot (4h)}$;

$4h = h'$; 4 is the answer

5. A 0.50-kg block is at rest at the bottom of a frictionless 30.0° inclined plane. A physics student performs 4.0 J of work moving the block a distance *s* along the inclined plane. At the end of the process the velocity of the block is zero. Determine the value of *s*.

A) 8.0 cm

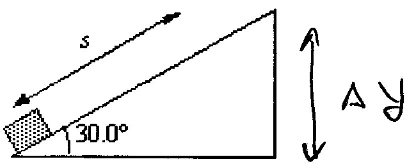
B) 16 cm

C) 82 cm

D) 160 cm

E) 330 cm

$\Delta U = W_{external}$



$\Delta U = mg\Delta y$

$\Delta y = S \cdot \sin 30°$

$\Delta U = mg \cdot S \cdot \sin 30°$

$$S = \frac{W_{ext}}{mg \cdot \sin 30°} = \frac{4.0\,J}{0.5\,kg \cdot 9.8\,\frac{m}{s^2} \cdot 0.5} =$$

$$= 1.6\,m = \underline{160\,cm}$$

6. A warehouse worker uses a forklift to lift a crate of pickles on a platform to a height 2.75 m above the floor. The combined mass of the platform and the crate is 207 kg. If the average power expended by the forklift is 1440 W, how long does it take to lift the crate?

$P = \frac{W}{\Delta t}$; $\underset{\text{(work)}}{W} = \Delta U = Mg\Delta y$

$\Delta t = \frac{W}{P} = \frac{Mg\Delta y}{P} = \frac{207 \cdot 9.8 \cdot 2.75}{1440} s =$

$= \underline{3.87\ s}$

A) 37.2 s

B) 5.81 s

C) 3.87 s

D) 18.6 s

E) 1.86 s

7. A particle moves 5 m in the +*z* direction while being acted upon by a constant force **F**= (4 N)**i** + (2 N)**j** – (4 N)**k**. The work done on the particle by this force is:

$\vec{d} = 5m \cdot \hat{k}$

$\vec{F} = (4N)\hat{i} + (2N)\hat{j} - (4N)\hat{k}$

$\vec{F} \cdot \vec{d} = (5m) \cdot \hat{k} \cdot (-4N) \cdot \hat{k} =$

$= \underline{-20\ J}$

A) 20 J

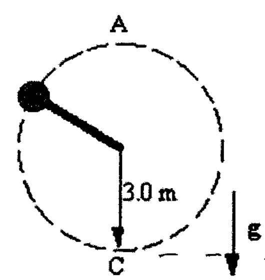
B) 10 J

C) –20 J

D) 30 J

E) –80 J

8. A 0.50-kg ball on the end of a rope is moving in a vertical circle of radius 3.0 m near the surface of the earth where the acceleration due to gravity, *g*, is 9.8 m/s^2. Point **A** is at the top of the circle; **C** is at the bottom. The ball moves on the circle from **A** to **C** under the influence of gravity alone. If the kinetic energy of the ball is 35 J at **A**, what is its kinetic energy at **C**?



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$K = \frac{mv^2}{2}$ at A

$U = mg \cdot 2r$ at A

$K_A + U_A = K_C + U_C$

$U_C = 0$

$K_C = K_A + U_A = 35J + (0.5 \cdot 9.8 \cdot 2 \cdot 3)J =$

$= 35J + 29.4J = \underline{64\ J}$

A) zero joules

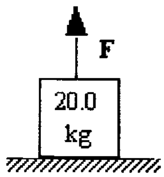
B) 29 J

C) 35 J

D) 44 J

E) 64 J

9. A rope exerts a force **F** on a 20.0-kg crate. The crate starts from rest and accelerates upward at 5.00 m/s^2 near the surface of the earth. How much work has been done by the force **F** in raising the crate 4.0 m above the floor?



$F_{net} = F - mg \; ; \; F_{net} = m \cdot a$

$ma = F - mg \; ; \; F = m(a+g)$

$W_F = F \cdot d \cdot \cos\theta \; ; \; \cos\theta = 1 \; (\theta = 0°)$

$W_F = m(a+g) \cdot d = (20 \cdot (5+9.8) \cdot 4)\,J$

$= 1184\,J \approx \boxed{1180\,J}$

A) 388 J

B) 250 J

C) 116 J

D) 704 J

E) 1180 J

10. A 60-kg person drops from rest a distance of 1.20 m and lands on a platform of negligible mass supported by a stiff spring. The person + platform then move 6 cm as their speed reduces to zero for the first time. What is the value of the spring constant ?

A) 8.83 x 10^4 N/m

B) 5.45 x 10^4 N/m

C) 4.12 x 10^5 N/m

D) 2.56 x 10^5 N/m

E) 3.92 x 10^5 N/m

$U_g = mg\Delta y \; ; \; \Delta y = 1.26\,m$

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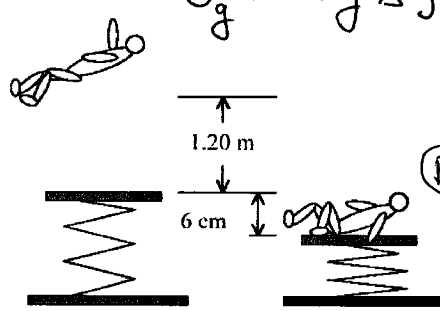

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--- Ø level of Potential Energy

$U_s = \frac{kx^2}{2}$

$U_{g\,A} + U_{s\,A} = U_{g\,B} + U_{s\,B}$

$mg\Delta y = \frac{kx^2}{2}$

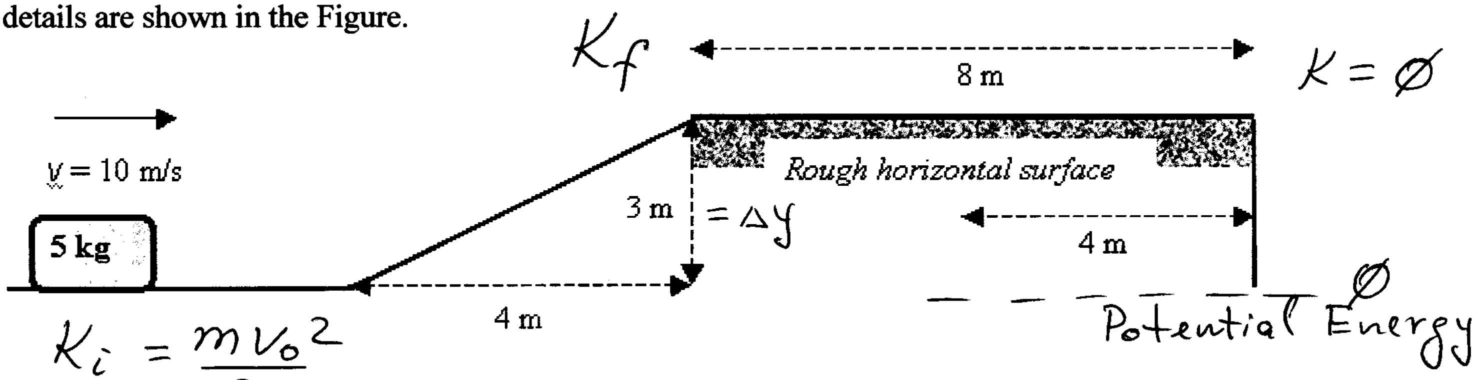
$k = \frac{2mg\Delta y}{x^2} = \frac{2 \cdot 60\,kg \cdot 9.8\,\frac{m}{s^2} \cdot 1.26\,m}{(0.06\,m \cdot 0.06\,m)} =$

$= \underline{4.12 \times 10^5\,N/m}$

Workout Problem # 1 (10 points)

Important note: ***use Work-Energy concepts to get credit for solution of this Problem !***

A 5.0 kg-crate slides along a horizontal frictionless surface at a constant speed of 10 m/s. The crate then slides up a frictionless incline and across a second rough horizontal surface. The details are shown in the Figure.



$K_i = \dfrac{m V_0^2}{2}$

a) What is the speed and Kinetic Energy of the crate when it arrives at the upper surface ?

$K_i + U_i = K_f + U_f \qquad U_i = \varnothing\,; \quad K_f = K_i - mg\Delta y$

$K_f = \dfrac{mV_0^2}{2} - mg\Delta y = \left(\dfrac{5\,kg\,(10\,\frac{m}{s})^2}{2} - 5\,kg \cdot 9.8\,\frac{m}{s^2} \cdot 3\,m\right) = 103\,J \approx 100\,J$

$V_f = \sqrt{\dfrac{2K_f}{m}} = \sqrt{\dfrac{2 \cdot 103\,J}{5\,kg}} \approx 6.4\ m/s$

Speed of the crate = $6.4\,\frac{m}{s}$ *Kinetic Energy of the crate* = $100\,J$

b) What minimum coefficient of kinetic friction μ_k is required to bring the crate to stop over a distance of 8.0 m along the *upper* surface preventing the crate from falling off the edge?

To stop the crate, the work of the f_K force should be equal to: $-K_f$; $W_{f_K} = -f_K \cdot d = -\mu_K \cdot mg \cdot d$

$\mu_K = \dfrac{K_f}{mg \cdot d} = \dfrac{103\,J}{5\,kg \cdot 9.8\,\frac{m}{s^2} \cdot 8\,m} \approx 0.26$

kinetic friction μ_k = 0.26

c) What is the Kinetic Energy of the crate 4 m away from the edge of the upper surface? For full credit use the coefficient of kinetic friction from the part (b) or use μ_k = 0.15 for partial credit.

$K' = K_f - f_K \cdot d' = K_f - \mu_K \cdot mg \cdot d' =$

$= K_f - \dfrac{K_f \cdot mg}{mg \cdot d} \cdot d' = K_f \cdot \left(1 - \dfrac{d'}{d}\right) =$

$= K_f \cdot 0.5 \approx 51.5\,J$

Kinetic Energy of the crate = $52\,J$

for $\mu_K = 0.15$ $\quad K = 74\,J$

Workout Problem #2 (10 points)

A student has proposed a design for an automobile crash barrier. When a 1200 kg car moving at 20 m/s crashes into it, a stiff spring of negligible mass attached to the barrier slows the car to a stop. The spring constant k is 7200 N/m. In the following analysis ignore friction between the car and the ground.

A) What is the change in kinetic energy of the car when the car is slowed down to a stop by the spring?

$$\Delta K = K_f - K_i = \emptyset - \frac{m v_o^2}{2} = -\frac{m v^2}{2} =$$

$$= -\frac{1200\ kg \cdot 400\ \frac{m^2}{s^2}}{2} = \underline{-2.4 \cdot 10^5\ J}$$

B) What is the change in gravitational potential energy of the car?

$\Delta U = \emptyset$ The gravitation force is doing zero work since there is no displacement in vertical direction

C) Find the distance that the spring compresses in bringing the car to a stop. [redacted]

[redacted] $K_i = U_{spring}$; $\frac{m v_o^2}{2} = \frac{K x_o^2}{2}$; $x_o = v_o \cdot \sqrt{\frac{m}{K}}$

$$x_o = 20\ \frac{m}{s} \cdot \sqrt{\frac{1200\ kg}{7200\ kg/s^2}} = 8.2\ m$$

D) If friction between the car and the ground could not be ignored, how would this change your answer to part (C) about the distance of the spring compression. Clearly justify your answer with the appropriate equation. Friction force will do some work decreasing the Kinetic Energy of the car.

So $\frac{K x_1^2}{2} = \frac{m v^2}{2} - W_{fk}$; $x_1 = \sqrt{\frac{m}{K} v^2 - 2 W_{fk}} < x_o$

The compression of the spring decreases due to friction

E) How would your answer to part (C) change if the spring constant were smaller? Clearly justify your answer with the appropriate equation(s).

$x = v_o \cdot \sqrt{\frac{m}{K}}$, if K is smaller then x is larger.

for example, if K decreases by a factor of 4, then x will increase by a factor of 2.