Physics 101 Second Test: November 7, 2000. **Time allowed: 90 minutes.**

(1) Print your LAST and FIRST names on the front of your blue book, on this question sheet and the multiple-choice question sheet.
(2) The test consists of two free-response questions plus ten multiple-choice questions.
(3) The test is graded on a scale of 100 points; each free-response question accounts for 35 points and each multiple-choice question accounts for 3 points.
(4) Answer the two free-response questions in the blue book; answer the 10 multiple-choice questions by circling the single most nearly correct answer on the multiple-choice-question sheet directly.
(5) Consult no books or notes of any kind. You may use a hand calculator in non-programmed and non-graphing mode.
(6) Do NOT take any of the test materials out of the room at any time. Return questions sheets with your blue book and the multiple-choice-question answer sheet.
(7) Write and sign the pledge on the front of your blue book.

LAST NAME: ______________________ FIRST NAME: ____________________
(PLEASE PRINT)

Show your work, including neat and clearly labeled figures on the free-response questions. Even correct answers without explanation may be denied credit.

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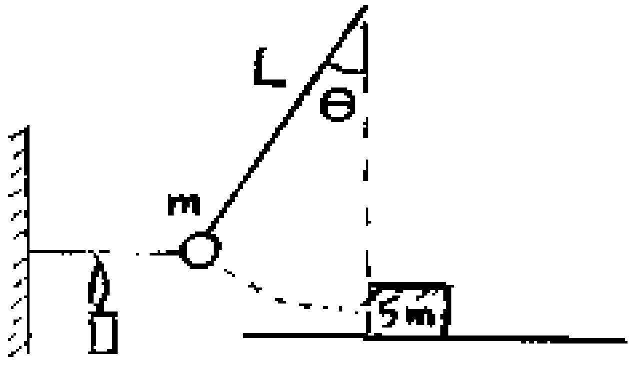
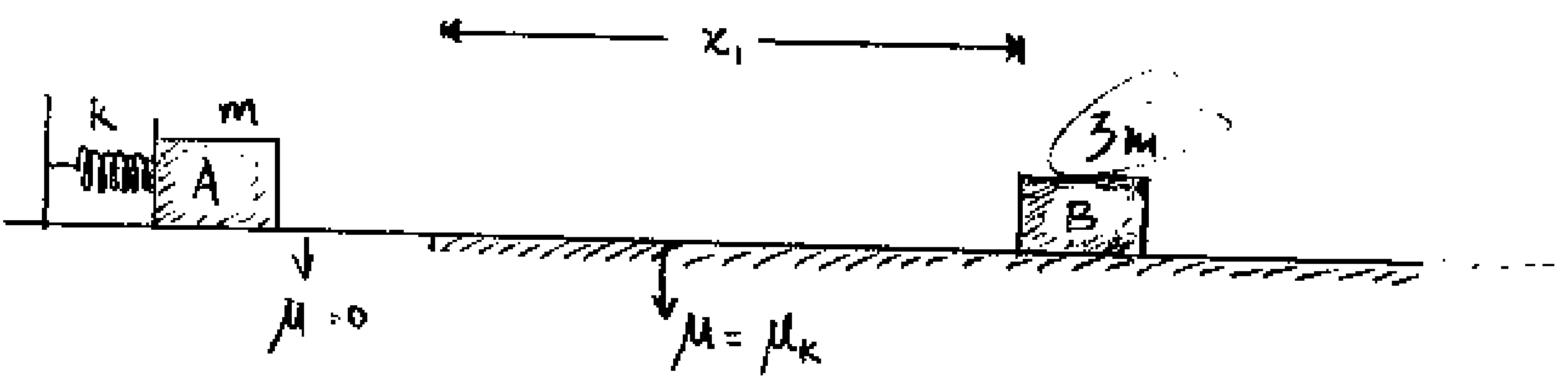
1. A small ball of mass m is attached to a light cord of length L. It is held at rest with a horizontal string, so that the angle between the cord and the vertical is θ. The horizontal string is then cut using a candle. The ball swings down and collides with a block of mass 5m resting on a smooth horizontal surface directly below the point of suspension of the ball. The ball rebounds such that immediately after the collision, it has half the speed with which it hit the block. Let the value of the acceleration due to gravity be g.

a) Determine the tension in the cord before the horizontal string is cut.
b) Determine the tension in the cord immediately after the string is cut.
c) Determine the acceleration vector for the ball immediately after the string is cut.
d) Determine the tension in the cord immediately before the ball collides with the block.
e) Determine the fraction of the kinetic energy lost in the collision between the ball and block.
f) Determine the maximum angle θ_2 between the cord and the vertical when the ball swings back up.



2. Block A of mass m is used to compress a spring (of spring constant k) so that it can be launched with velocity v_0 across a frictionless surface. Block A then travels a distance x_1 across a rough surface with coefficient of friction μ_k before colliding with Block B of mass 3m. After the collision, both blocks A and B travel the same distance in opposite directions on this rough surface before coming to rest. Let the value of the acceleration due to gravity be g.

a) Determine the distance d through which the spring was compressed. Express your answer in terms of some or all of the quantities m, k, v_0, x_1, μ_k, and g.
b) Determine the velocity v_1 of Block A just before it collides with Block B. Express your answer in terms of some or all of the quantities m, k, v_0, x_1, μ_k, and g.
c) Determine the velocity v_2 of Block A just after the collision with Block B. Express your answer in terms of some or all of the quantities m, v_1, μ_k, and g.
d) Determine the velocity v_3 of Block B just after the collision with Block A. Express your answer in terms of some or all of the quantities m, v_1, μ_k, and g.
e) Determine if the collision between Blocks A and B was elastic.



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TEN MULTIPLE CHOICE QUESTIONS. For each of the following questions, circle (on this sheet) the option that is most nearly correct.

1. An astronaut drops a rock from the top of a cliff on the Moon. When the rock is halfway down to the bottom of the cliff, its speed is what fraction of its final impact speed?

a) $\frac{1}{4\sqrt{2}}$ b) $\frac{1}{4}$ c) $\frac{1}{2\sqrt{2}}$

d) $\frac{1}{2}$ e) $\frac{1}{\sqrt{2}}$

2. A force of 200 N is required to keep an object sliding at a constant speed of 2m/s across a rough floor. How much power is being expended to maintain this motion?

a) 50 W b) 100 W c) 200 W

d) 400 W e) Cannot be determined from information given.

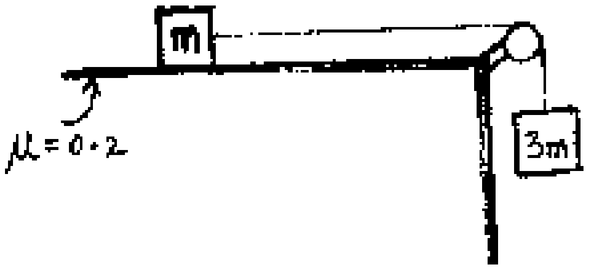


Figure for Question 3

3. In the figure above, the coefficient of sliding friction between the small block and the tabletop is 0.2. Let the pulley be frictionless and massless and g be the value of the acceleration due to gravity. What will be the acceleration of the blocks once the blocks are released from rest?

a) 0.5g b) 0.6g c) 0.7g

d) 0.8g e) 0.9g

4. Two people, one of mass 100kg and the other of mass 50kg, stand facing each other on an ice-covered pond (frictionless surface). If the heavier person pushes on the lighter one with force $\bar{F}$, then

a) the force felt by the heavier person is $-\frac{\bar{F}}{2}$.

b) the force felt by the heavier person is $-2\bar{F}$.

c) the magnitude of the acceleration of the lighter person will be half the magnitude of the acceleration of the heavier person.

d) the magnitude of the acceleration of the lighter person will be twice the magnitude of the acceleration of the heavier person.

e) None of the above.

5. An astronaut lands on a planet whose mass and radius are each twice that of Earth. If the astronaut weight 800 N on Earth, how much will she weigh on this planet?

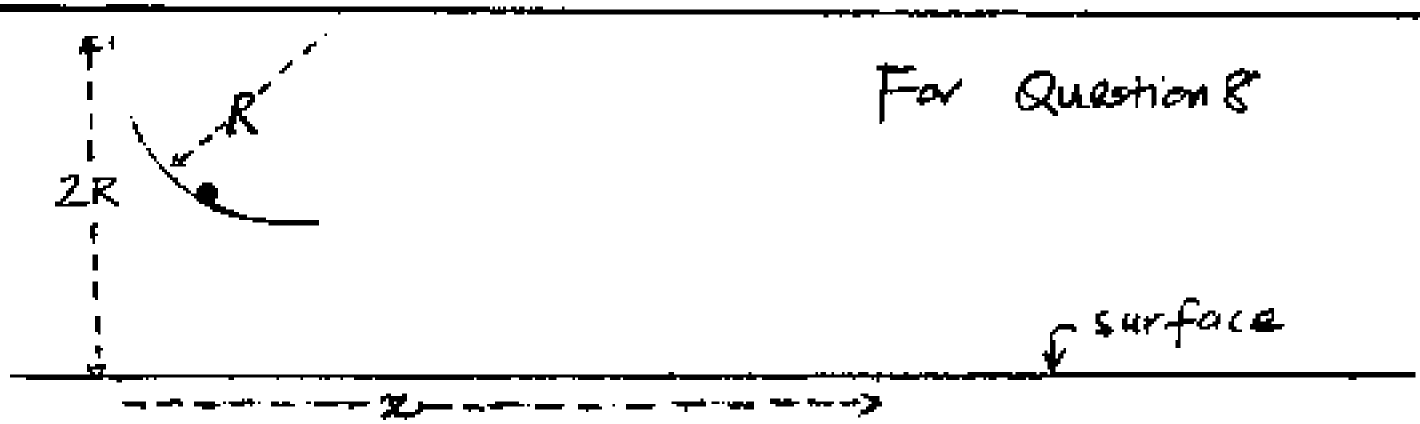
a) 200 N
b) 400 N
c) 800 N
d) 1600 N
e) 3200 N

6. An object of mass 2 kg increases in speed from 2 m/s to 4 m/s in 3 s. Determine the total amount of work performed on this object during this time interval

a) 4 J
b) 6 J
c) 12 J
d) 36 J
e) Cannot be determined from information given.

7. Why do baseball catchers wear a mitt rather than just using their bare hands to catch a pitched baseball?

a) The impulse delivered to the catcher's hand is reduced due to the presence of the mitt.
b) The baseball's change in momentum is reduced due to the presence of the mitt.
c) The force on the catcher's hand is reduced because the mitt increases the time of impact.
d) The force on the catcher's hand is reduced because the mitt decreases the time of impact.



8. In the figure above, a small ball slides down a frictionless quarter-circle slide of radius R. If the ball starts from rest at a height equal to 2R above a horizontal surface, find its horizontal displacement, x, at the moment it strikes the surface.

a) 3R/2
b) 5R/2
c) 3R
d) 7R/2
e) 4R

9. An object of mass m is travelling at a constant speed v in a circular path of radius r. How much work is being done by the radially directed (centripetal) force during one-half of a revolution?

a) πmv^2
b) $2\pi mv^2$
c) 0
d) $\pi mv^2 r$
e) $2\pi mv^2 r$

10. In the figure shown, two objects are moving towards each other with velocities given by the vectors $\vec{v}_1$ and $\vec{v}_2$ on a frictionless surface. They collide perfectly inelastically at the indicated point and then move together as indicated by the vector $\vec{v}_3$. If the mass $m_1 = 2m_2$, then the relationship between the magnitudes of the initial velocities v_1 and v_2 can be written as

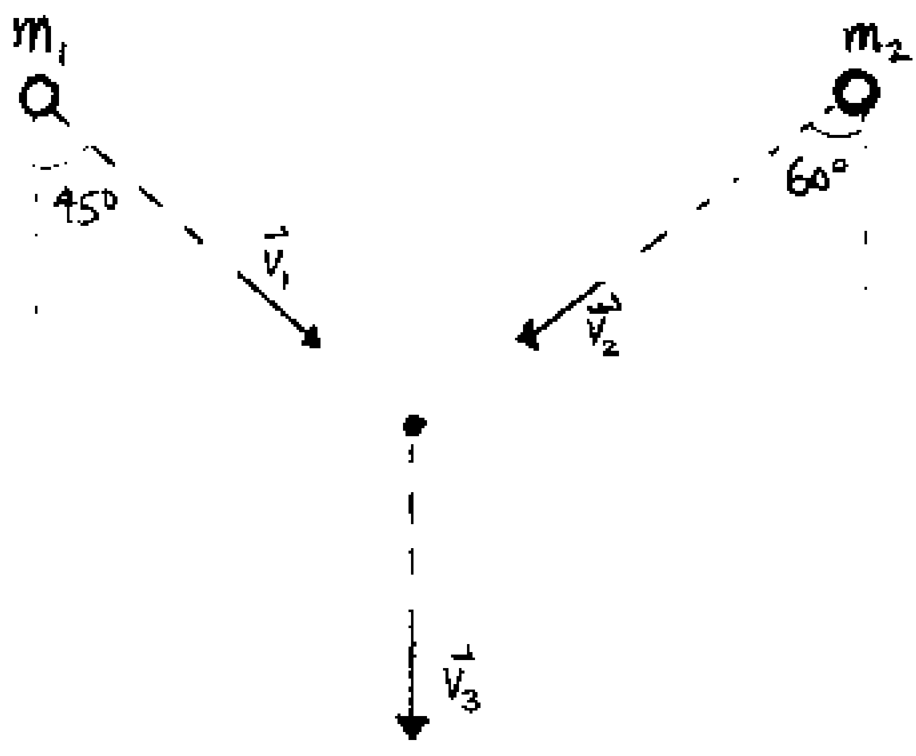
a) $\frac{v_2}{v_1} = \frac{\sin 45^\circ}{2\sin 60^\circ}$

b) $\frac{v_2}{v_1} = \frac{\cos 45^\circ}{2\cos 60^\circ}$

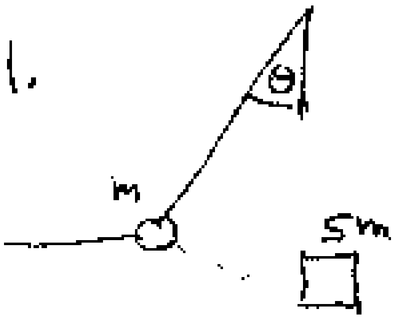
c) $\frac{v_2}{v_1} = \frac{2\cos 45^\circ}{\cos 60^\circ}$

d) $\frac{v_2}{v_1} = \frac{2\sin 45^\circ}{\sin 60^\circ}$

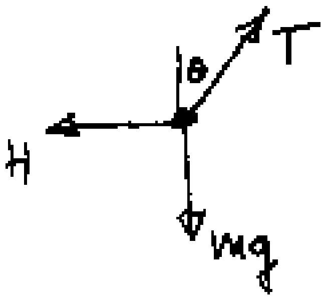
e) $\frac{v_2}{v_1} = \frac{\cos 45^\circ}{2\sin 60^\circ}$



1.

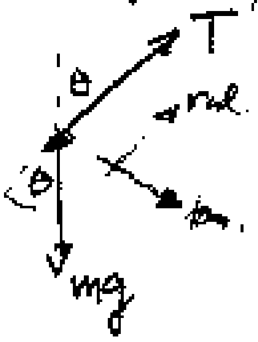


(a)



vert: $T\cos\theta - mg = 0 \Rightarrow \boxed{T = mg/\cos\theta}$

(b)

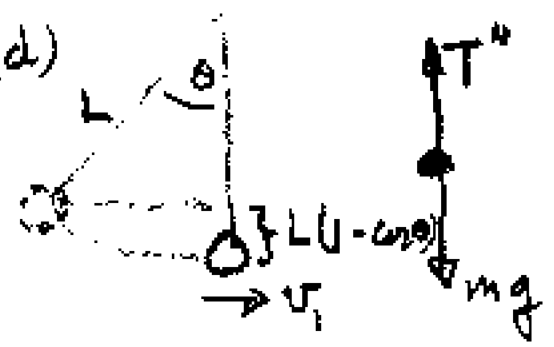


radial: $T' - mg\cos\theta = m\frac{v_0^2}{L}$ and $v_0 = 0$ } $\boxed{T' = mg\cos\theta}$

(radial component of accel = 0) → $\boxed{a_{rad} = 0}$

(c) tangential: $mg\sin\theta = m\,a_{tan} \Rightarrow \boxed{a_{tan} = g\sin\theta}$

(d)



$T'' - mg = \frac{m v_1^2}{L} \Rightarrow T'' = m\left(g + \frac{v_1^2}{L}\right)$

So we need v_1; use conservation of energy:

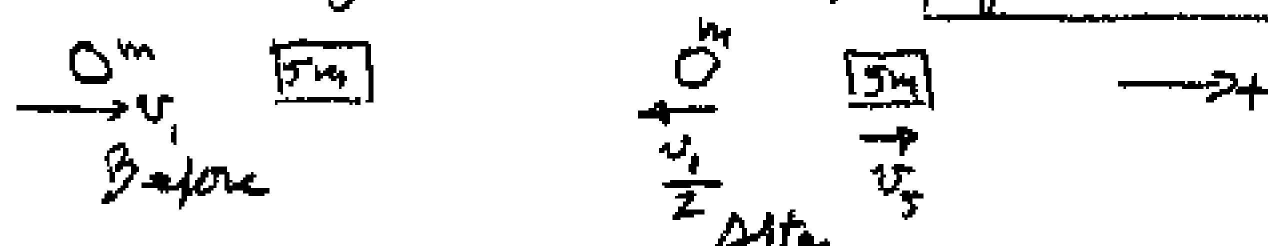
$K_i + U_i = K_f + U_f$

$0 + mgL(1-\cos\theta) = \frac{1}{2}mv_1^2 + 0$

$\Rightarrow v_1^2 = 2gL(1-\cos\theta)$

and $T'' = mg\,(1 + 2(1-\cos\theta)) = \boxed{mg(3 - 2\cos\theta)}$

(e) Collision



Conservation of momentum.

$m v_1 = -\frac{m v_1}{2} + 5m v_5 \Rightarrow v_5 = \frac{3v_1}{10}$

$K_{before} = \frac{1}{2}mv_1^2$, and $K_{after} = \frac{1}{2}m\left(\frac{v_1}{2}\right)^2 + \frac{1}{2}(5m)\left(\frac{3v_1}{10}\right)^2$

$= \frac{1}{2}mv_1^2\left(\frac{1}{4} + \frac{9}{20}\right) = \frac{1}{2}mv_1^2\left(\frac{7}{10}\right)$

So $\frac{\Delta K}{K_{bef}} = \frac{\frac{7}{10} - 1}{1} = \boxed{-\frac{3}{10}}$

(f) Conservation of energy: $\frac{1}{2}m\left(\frac{v_1}{2}\right)^2 = mgL(1-\cos\theta')$

make substitution: $\frac{m 2 g L (1-\cos\theta)}{8} = m g L (1-\cos\theta')$

$$1-\cos\theta' = \frac{1}{4}(1-\cos\theta)$$

$$\boxed{\theta' = \arccos\left[\frac{3+\cos\theta}{4}\right]}$$

Grading Criteria — Question 1, Test 2, F 2000

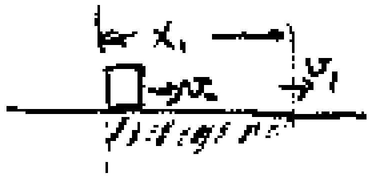
1 a)	FBD	2 points	5
	Newton's Laws	2 points	
	Ans	1 point	
b)	FBD	2 points	+ 6
	Newton's Laws	2 points	
	$V_0 = 0$	1 pts	
	Answer	1 point	
c)	Newton	2 points	+ 3
	Answer	1 point	
d)	FBD	2 points	+ 12
	Newton's Laws	2 points	
	$a = \frac{V^2}{L}$	2 points	
	Cons. of energy	2 points	
	Geometry	2 points	
	Answer	2 points	
e)	Cons. of mom	2 points	+ 5
	KE calc	2 points	
	Correct ans	1 point	
f)	Cons. of energy	2 points	+ 4
	Geometry	1 point	
	Ans	1 point	

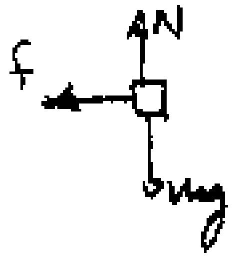
Total: 35

2.

(a) Conservation of energy: $\frac{1}{2}kd^2 = \frac{1}{2}mv_0^2 \Rightarrow \boxed{d = \sqrt{\frac{m}{k}}\,v_0}$

(b)





$f = \mu mg \qquad W_f = -fx_1 = -\mu mg x_1$

Work-energy theorem: $\Delta K = W$

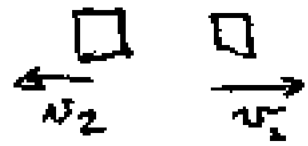
$$\frac{1}{2}mv_1^2 - \frac{1}{2}mv_0^2 = W_f = -\mu mg x_1$$

$$\Rightarrow \boxed{v_1 = \sqrt{v_0^2 - 2\mu g x_1}}$$

(c) Blocks slide the same distance (in opposite directions) after the collision.

we can determine $D = \frac{v_2^2}{2\mu g}$ (independent of mass)

So if they slide the same distance after the collision, they had the same speed after the collision, call it v_2



Now conservation of momentum tells us

$$mv_1 = -mv_2 + (3m)v_2 \Rightarrow v_2 = \frac{v_1}{2}$$

$\boxed{\text{m is moving to left with speed } \frac{v_1}{2} \text{ immediately after the collision}}$

(d) $\boxed{\text{3m is moving to right with speed } \frac{v_1}{2} \text{ immediately after the collision}}$

(e) "elastic" means $KE_i = KE_f$

$$KE_i = \frac{1}{2}mv_1^2 \qquad KE_f = \frac{1}{2}m\left(\frac{v_1}{2}\right)^2 + \frac{1}{2}(3m)\left(\frac{v_1}{2}\right)^2$$

$$= \frac{1}{2}mv_1^2\left(\frac{1}{4} + \frac{3}{4}\right)$$

$KE_i = KE_f$, so collision is $\boxed{\text{elastic}}$

Grading criteria Question 2, Test 2, F 2000

2 a)	Cons. of energy	2 pts	8
	Spring energy	2 pts	
	KE	2 pts	
	Answer	2 pts	
b)	W.E. Theorem or variations (or Mechanics, const acc.)	2 points	6
	Correct work done	2 points	
	Answer	2 points	
c + d	$D = \frac{v^2}{\mu g}$ (ind. of m, dep. on v)	5 pts	16
	Equal velocities	2 pts	
	Cons. of momentum	5 pts	
	Ans 1	2 pts	
	Ans 2	2 pts	
e)	Elastic ⇒ KE cons.	3 pts	5
	Correct ans.	2 pts	

35

Multiple choice, Test 2, Fall 2000

1. (e) , 2 (d) , 3 (c) , 4 (d) , 5 (b)

6 (c) , 7 (c) , 8 (c) , 9 (c) , 10 (d)