Physics 101 Fall 2003: Test 2—Free Response and Instructions

- Print your LAST and FIRST name on the front of your blue book, on this question sheet, the multiplechoice question sheet and the multiple-choice answer sheet.
- TIME ALLOWED 75 MINUTES
- The test consists of two free-response questions and ten multiple-choice questions.
- The test is graded on a scale of 100 points; the first free-response question accounts for 35 points, the second for 35 points, and the multiple-choice questions account for 30 points.
- Answer the two free-response questions in your blue book. Answer the multiple-choice questions by marking a dark X in the appropriate column and row in the table on the multiple-choice answer sheet.
- Consult no books or notes of any kind. You may use a hand-held calculator in non-graphing, non-programmed mode.
- Do NOT take test materials outside of the class at any time. Return this question sheet along with your blue book and multiple-choice question sheet.
- Write and sign the Pledge on the front of your blue book.

Show your work for the free-response problems, including neat and clearly labelled figures, in your blue book. It is possible that answers without explanation (even correct answers) will not be given credit.

Take $g = 9.8 \text{ m/s}^2$.

1. A student has placed a block of mass M = 1 kg and width $\Delta d = 0.1$ m at rest on a slope that makes an angle $\theta = 20^{\circ}$ to the horizontal as shown in the figure below. She plans to start the block down the slope by hitting it with a bullet.



Figure 1: Problem 1

She hits the block with a bullet of mass m = 5 g travelling parallel to the slope at 300 m/s. The bullet does not embed itself in the block but rather emerges travelling along its initial direction having lost 75% (three quarters) of its initial kinetic energy.

- (a) What is the velocity of the block (mass M) immediately after the bullet exits? (Assume the masses of the block and bullet are unchanged.)
- (b) What is the average force experienced by the bullet as it travels through the block?
- (c) If the block subsequently slides a distance s = 50 m down the incline before coming to rest, what is the coefficient of kinetic friction, μ_k , between the block and the plane?

Consider a uniform rod of mass m and length l at the end of which is glued a small ball, also of mass m. At its other end, the rod is attached to a fixed, friction-free pivot (O).
 Initially the rod is balanced vertically above the pivot and begins to fall (from rest) as shown in the

figure. (NOTE: The moment of inertia of a uniform rod pivoted about a perpendicular axis through its center is $\frac{mL^2}{12}$).



Figure 2: Problem 2

- (a) Find the angular acceleration of the rod/ball system as it passes through horizontal, i.e., as the ball reaches A.
- (b) Find the angular velocity of the rod/ball system as it passes through vertical, i.e., as the ball reaches B.

If the ball breaks free just as the rod passes through vertical, i.e., at point B

(c) What was the limiting strength of the glue bond holding the ball to the rod?

The rod continues to rotate

(d) At what angle to the horizontal does it next momentarily come to rest?

Multiple-Choice

- 1. A newly discovered planet has twice the mass of Earth, but the acceleration due to gravity on the new planet's surface is exactly the same as the acceleration due to gravity on Earth's surface. The radius of the new planet in terms of the radius R of Earth is
 - (a) R/2.
 - (b) $\sqrt{2}R/2$.
 - (c) $\sqrt{2}R$.
 - (d) 2R.
 - (e) 4R.
- 2. Joe throws a 0.15-kg rubber ball directly downward to the floor. The ball's speed just before impact is 6.5 m/s and just after the impact is 3.5 m/s. If the ball is in contact with the floor for 0.025 s, what is the magnitude of the average force that the floor exerts on the ball during the time of contact?
 - (a) 133 N
 - (b) 60 N
 - (c) 30 N
 - (d) 18 N
 - (e) 3.0 N
- 3. You are given two carts, A and B. They look identical, and you are told that they are made of the same material. You place A at rest on an air track and give B a constant velocity directed to the right so that it collides elastically with A. After the collision, both carts move to the right, the velocity of B being smaller than what it was before the collision. What do you conclude?
 - (a) Cart A is hollow.
 - (b) The two carts are identical.
 - (c) Cart B is hollow.
 - (d) need more information.
- 4. An object of mass m sits at a distance R from the axis of rotation on a record that is being played. The record makes a complete revolution in time T and friction holds the object in its place relative to the record. The coefficient of static friction between the object and the record is μ_s . How much work is done by friction in one revolution?
 - (a) none
 - (b) $4\pi^2 m R/T^2$
 - (c) $8\pi^3 m R^2 / T^2$
 - (d) $2\pi\mu_s mgR$
 - (e) $4\pi^2 \mu_s mg R/T^2$

- 5. A person pushes a box across a horizontal surface at a constant speed of 0.5 m/s. The box has a mass of 40 kg, and the coefficient of sliding friction is 0.25. The power supplied to the box by the person is
 - (a) 0.2 W
 - (b) 5 W
 - (c) 50 W
 - (d) 100 W
 - (e) 200 W
- 6. A uniform stick has a length L. The moment of inertia about the center of the stick is I_0 . A particle of mass M is attached to one end of the stick. The moment of inertia of the combined system about the center of the stick is
 - (a) $I_0 + \frac{1}{2}ML^2$.
 - (b) $I_0 + \frac{1}{4}ML^2$.
 - (c) $I_0 + \frac{3}{4}ML^2$.
 - (d) $I_0 + ML^2$.
 - (e) $I_0 + \frac{5}{4}ML^2$.
- 7. From the top of a 70 m high building, a 1 kg ball is thrown directly downward with an initial speed of 10 m/s. If the ball reaches the ground with a speed of 30 m/s, the energy lost to friction is most nearly
 - (a) 0 J.
 - (b) 100 J.
 - (c) 300 J.
 - (d) 400 J.
 - (e) 700 J.
- 8. A satellite moves in a stable orbit with speed v_0 at a distance R from the center of a planet. For this satellite to move in a stable circular orbit a distance 2R from the center of the planet, the speed of the satellite must be
 - (a) $\frac{v_0}{2}$.
 - (b) $\frac{v_0}{\sqrt{2}}$.
 - (c) v_0 .
 - (d) $\sqrt{2v_0}$.
 - (e) $2v_0$.

Questions 9-10

A cylinder rotates with constant angular acceleration about a fixed axis. The cylinder's moment of inertia about the axis is 4 kg m². At time t = 0 s the cylinder is at rest. At time t = 2 s its angular velocity is 1 rad/s.

- 9. The angular acceleration of the cylinder between t = 0 s and t = 2 s is
 - (a) 0.5 rad/s^2 .
 - (b) 1 rad/s^2 .
 - (c) 2 rad/s^2 .
 - (d) 4 rad/s².
 - (e) 5 rad/s^2 .

10. The kinetic energy of the cylinder at time t = 2 s is

- (a) 1 J.
- (b) 2 J.
- (c) 3 J.
- (d) 4 J.
- (e) It cannot be determined without knowing the radius of the cylinder.

Problem #1-35 pts
Variable :
$$V_{\mu} = \text{velocity of bullet (initial)}$$

 W_{μ} $W_{\mu} = \text{velocity of bullet (initial)}$
 $W_{\mu} = \text{mean of bullet}$
 $M = \text{mean of bu$

Problem # 1
(b) Finuld = Fo
For = mab
$$a_{10} = Receivering experienced by ballit an it peritodes
back.
What is $a_{10}?$
We can get a_{10} by vary Khumati equation (why?)
 $V_{1}^{2} = v_{1}^{2} + 2a(x-x_{0})$
 $\Rightarrow U_{10}^{2} = V_{10}^{2} + 2a_{10}(\Delta d)$
 $\Rightarrow a_{10} = \frac{u_{10}^{2} - v_{11}^{2}}{2 \Delta d} = -357,500 \text{ m/s}^{2}$
 $=> 50$ Fo = $(0.005 \text{ kg})(-327,500 \text{ m/s}^{2}) = -10675 \text{ N}$
Note: the minus sign implies a Assistive form!
Also Fo = $\frac{A_{10}}{\Delta t} = \frac{m_{10}(\Delta v)}{\Delta t} = \frac{m_{10}(u_{10} - v_{11})}{\Delta t} = \frac{m_{10} a_{10}}{\Delta}$
 $= \frac{M_{10} - v_{11}}{\Delta} = \frac{M_{10} (\Delta v)}{\Delta t} = \frac{M_{10} - v_{11}}{\Delta} = \frac{4.444440}{2} \text{ m}^{2} \text{ s}^{2}$
Method (2) Work - Gragg Them
 $\Delta K + \Delta U = \Delta E$ $\Delta E \neq 0$
 $\Rightarrow \Delta K = \Delta E = W_{10}$ Britted expressions a fire-treat
 $f^{m_{10}} (u_{10}^{2} - v_{10}^{2}) = f_{10} \Delta T = -F_{10} \Delta (-F_{10} \text{ spress match})$
 $\Rightarrow F_{10} = -\frac{m_{10}(u_{10} - v_{11})}{2\Delta d} \Rightarrow F_{10} = 106750 \text{ (corres match)}$$$



 $ZF_{L}: N-Wus Q = Ma_{L}(a_{L}=0)$ => N=WLOS Q

$$\mathbb{Z}F_{II}$$
: $WsinQ - f = Ma_{II}$ $(a_{II} \neq 0)$

$$a_{11} = ? \quad \text{Kinimatics } \{ \text{ubistant } a \}$$

$$V_{f}^{2} = V_{o}^{2} + Za \{ x - x_{o} \}$$

$$O = \nabla^{2} + 2a_{11} S$$

$$\Rightarrow a_{11} = -\frac{\nabla^{2}}{ZS} \quad (\text{opposer Multim})$$

$$\Rightarrow Q_{11} = -5.625 \times 10^{3} \text{ m/s}^{2}$$

$$f = W \sin Q - M \alpha_{H} = (I \omega_{J})(g) \sin 20^{\circ} - 1 kg (-5.625 \times 10^{\circ} m/s^{\circ})$$

$$f = 3.357 N$$

$$f = \mu_{K} N = \mu_{K} W \cos Q$$

$$\Rightarrow \mu_{R} = \frac{f}{W \cos Q} = \frac{0.36}{2}$$

Problem #1
(c) Although Method

$$\Delta K + \Delta U = \Delta E \neq 0$$

 $\frac{1}{2} M (y_4^2 - \nabla^2) + M g (y_4 - y_1) = W_{nc} = \hat{f} \cdot \hat{s} = -fs$
 $-\frac{1}{2} M \cdot \nabla^2 + M g (-h) = -fs = -M_R N s = -M_R \cdot M g \ll 0 s$
 $\Rightarrow M_R = \frac{1}{2} \nabla^2 + gh$
 $gs \cos \theta$
 $h = ?$
 $M = \frac{1}{2} \frac{\nabla^2 + gh}{gs \cos \theta}$
 $h = s \sin \theta$



Problem# Z



Problem # 2
(b)

$$3e^{2} \sqrt{2}e^{2} \sqrt{2}e^{2}$$

Probalim # Z

 $\frac{1}{2} \operatorname{Tree}(w_{f}^{2} - w_{e}^{2}) + mg(y_{em_{f}} - y_{em_{f}}) = 0$ $w_{f}^{2} = 0 \qquad w_{e} = w_{h} \quad (w_{hy}^{2}) \qquad y_{em_{f}}^{2} - y_{em_{f}}^{2} = h$

$$= \frac{1}{2} \operatorname{Ind} w_{b}^{2} = - \operatorname{mgh}$$

$$h = \frac{1}{2} \operatorname{mg}^{2} \frac{1}{2} \frac{1$$

This means the center of man for the hod has moved a vertical altestance of 34



=>
$$Ain O = \frac{2}{4} = \frac{1}{2}$$

$$= 30^{\circ} = \sin^{1}(0.5) = 30^{\circ}$$

(d)

Roc' makes a 30° angle w.r.t. the horizonal "¿ Does not make it back to vertical \$44



Physics 101 Fall 2003: Test 2—Multiple-Choice Answers 7:45 AM, 18 November, 2003

For each question, mark a single X in the box corresponding to the correct answer.

