Name:_____ ID:_____ Lab (day/time)_____

Physics 201

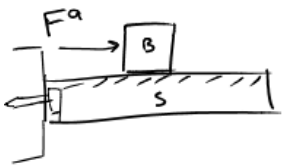
Final Exam

7/16/2014

Collaboration is not allowed. Allowed on your desk are: up to ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating/graphing scientific calculator, 1 page of scratch paper, writing utensils, and the exam. You will have 110 minutes to complete this exam.

1. (8 points) The following statements regarding the work done by friction on some object are all true. For each statement, give an example of a case where it is true. Explain how it proves the statement to be true.

   (a) Static friction can do zero work on an object.



Both the blocks & the slab are stationary, w/ $W_{fs} = \vec{F}_{f,s} \cdot \Delta\vec{r} + \Delta\vec{r} = 0$, $W_{fs} = 0$

   (b) Static friction can do non-zero work on an object.

   (c) Kinetic friction can do positive work on an object.

For questions 3 through 6 circle all correct answers, a given problem may have more than one correct answer. Each correctly circled answer will receive two points. There are **11** correct answers in this section and only the first **11** circled answers will be graded. There is no partial credit.

2. Complete the following statement: A force that acts on an object is said to be conservative if
   [N] (a) it obeys Newton's laws of motion.
   [N] (b) it results in a change in the object's kinetic energy.
   [N] (c) it always acts in the direction of motion of the object.
   [Y] (d) the work it does on the object is independent of the path of the motion.
   [N] (e) the work it does on the object is equal to the increase in the object's kinetic energy.

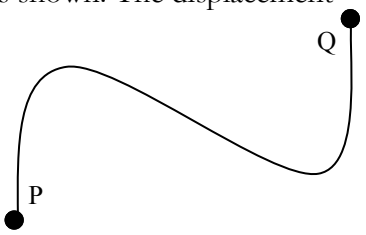
3. A baseball hit upward at some angle (less than 90º) above ground level travels along a parabolic arc before it strikes the ground. Considering the ball while in flight, which of the following statements are true?
   [T] (a) In the absence of air resistance, the acceleration of the ball is constant through its flight.
   [F] (b) The kinetic energy of the ball reaches a zero when the ball is at the highest point in the arc.
   [F] (c) The acceleration of the ball is momentarily zero when the ball is at the highest point in the arc.
   [T] (d) In the absence of air resistance, the x-component of the velocity of the ball is the same throughout the ball's flight.
   [F] (e) The acceleration of the ball is maximum when the ball is at the highest point in the arc.
   [F] (f) In the presence of air resistance, the downward component of the acceleration of the ball will still be constant but will be less than 9.8 m/s^2.

4. A father and daughter are stationary on frictionless ice facing each other. If they push off from each other horizontally, which of the following statements is false.
   [T] (a) The acceleration of the center of mass of the father is less than that of the daughter.
   [F] (b) The acceleration of the center of mass of the father is zero, while the daughter's is not zero.
   [T] (c) The acceleration of the center of mass of the father + daughter system is zero.
   [T] (d) The point where their hands meet does not move.

5. A rock of mass ***m***, is connected to a string of length ***r***, that is pulled taught horizontally. The rock is then released from rest and swings back and forth along a circular arc, like a pendulum. Do not ignore the effects of air resistance. Which of the following statements are true.
   [F] (a) The string will do the maximum amount of work at the bottom of the arc.
   [F] (b) The acceleration of the rock points towards the center of the circular arc right after it is released.
   [T] (c) Right when the rock is released is the only time the string will be horizontal.
   [F] (d) Air resistance does positive work on the rock as it swings downward and negative work on the rock as it swings upward.
   [T] (e) Once the rock has comes permanently to rest, the increase in thermal energy to the environment is equal to ***mgr***.

6. A ball is whirled on the end of a string in a nearly horizontal circle of radius **R** at constant speed **v**. The radial acceleration of the ball can be increased by a factor of 4 by
   [N] (a) keeping the speed fixed and increasing the radius by a factor of 4.
   [N] (b) keeping the radius fixed and increasing the speed by a factor of 4.
   [N] (c) keeping the radius fixed and increasing the period by a factor of 4.
   [N] (d) keeping the radius fixed and decreasing the period by a factor of 4.
   [Y] (e) keeping the speed fixed and decreasing the radius by a factor of 4.

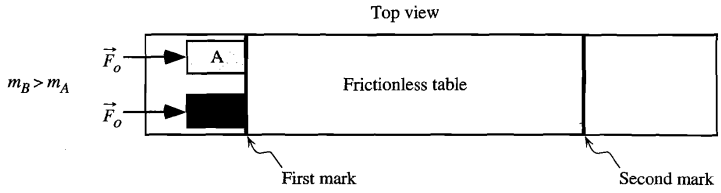
7. A particle travels along a curved path between two points P and Q as shown. The displacement of the particle does *not* depend on
   [F] (a) the location of P.
   [F] (b) the location of Q.
   [T] (c) the distance traveled from P to Q.
   [F] (d) the shortest distance between P and Q.
   [F] (e) the direction of Q from P.



8. A gerbil in your hand is being raised up at a constant velocity. Which of the following statements are true regarding this situation?
   [F] (a) The normal force on the gerbil must be larger than the gravitational force.
   [F] (b) The impulse acting on the gerbil is zero.
   [T] (c) The gerbil travels through equal distances over equal time intervals.
   [T] (d) The normal force does positive work on the gerbil.
   [F] (e) The kinetic energy of the gerbil increases from one second to the next.

9. A stationary bomb explodes in gravity-free space breaking into a number of small fragments. Which of the following statements concerning this event is true?
   [F] (a) Kinetic energy is conserved in this process.
   [F] (b) The fragments must have equal kinetic energies.
   [F] (c) The sum of the kinetic energies of the fragments must be zero.
   [T] (d) The vector sum of the linear momentum of the fragments must be zero.
   [F] (e) The velocity of any one fragment must be equal to the velocity of any other fragment.

10. (8 points) Two carts, A and B, are initially at rest on a horizontal frictionless table as shown in the top-view diagram below. A constant force of magnitude F_o is exerted on each cart as it travels between two marks on the table. Cart B has a greater mass than cart A.



(a) Which cart takes longer to travel between the two marks? Explain your reasoning.

w/ $\Sigma\vec{F} = m\vec{a}$ & $m_B > m_A$, so $\vec{a}_A > \vec{a}_B$ & w/ $\Delta x = \cancel{v_i \Delta t}^{0} + \frac{1}{2}a\Delta t^2$

& $\Delta x_A = \Delta x_B$, $\Delta t_B > \Delta t_A$

(b) Is the magnitude of the impulse imparted to cart A *greater than, less than*, or *equal to* the magnitude of the impulse imparted to cart B? Explain your reasoning.

$J = \Sigma \vec{F}\,\Delta t$ & $\Sigma \vec{F}_A = \Sigma \vec{F}_B$, $\Delta t_A < \Delta t_B$, so $J_A < J_B$

less than

(c) Is the kinetic energy of cart A *greater than, less than*, or *equal to* the kinetic energy of cart B after they have passed the second mark? Explain your reasoning.

$\Sigma E_i + W_{nc} = \Sigma E_f \Rightarrow W_{nc} = \Delta E = \Delta K + \cancel{\Delta U}^{0}$

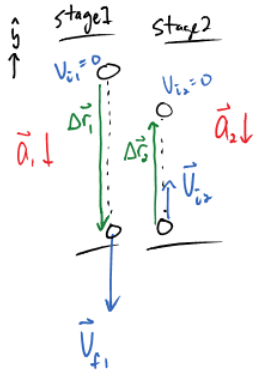
$W_{nc} = \Sigma \vec{F}_{nc} \cdot \Delta\vec{r} = |\vec{F}_o|\,|\Delta\vec{r}|\,\cancel{\cos\theta}^{1} = |\vec{F}_o|\,|\Delta\vec{r}|$

$\Delta\vec{r}_A = \Delta\vec{r}_B$, $\vec{F}_{oA} = \vec{F}_{oB}$, so

$W_{nc_A} = W_{nc_B}$ & $\Delta K_A = \Delta K_B$

equal to

11. (12 points) A 0.500-kg ball is dropped from rest at a point 1.20 m above the floor. The ball rebounds straight upward to a height of 0.700 m. (a) What are the magnitude and direction of the impulse of the net force applied to the ball during the collision with the floor? (b) How much mechanical energy is lost during the collision with the floor?



a.) $\vec{J} = \Delta\vec{p} = m(\vec{v}_f - \vec{v}_i)$, $\vec{v}_f = \vec{v}_{i2} + \vec{v}_i = \vec{v}_{f1}$, $\vec{a}_1 = \vec{a}_2 = \vec{a}$

Stage 1 (free fall down)

k	uk
$a_y = -9.8\,m/s^2$	v_{f1y}
$v_{i1y} = 0$	Δt_1
$\Delta y_1 = -1.2m$	

10

$v_{f1y}^2 = v_{i1y}^2 + 2a\Delta y_1$

$v_{f1y} = \pm\sqrt{2g\Delta y_1} = -4.85\,m/s$

Stage 2 (free-fall up)

k	uk
$a_y = -9.8\,m/s^2$	v_{i2y}
$v_{f2y} = 0$	Δt_2
$\Delta y_2 = +0.7m$	

$v_{f2y}^2 = v_{i2y}^2 + 2g\Delta y_2$

$v_{i2y} = \sqrt{-2g\Delta y} = 3.70\,m/s$

Vector op (collision)

$\Delta p_y = p_{fy} - p_{iy} = m(v_{fy} - v_{iy}) = 4.28\,\frac{kg\cdot m}{s}$, $\Delta p_x = 0$

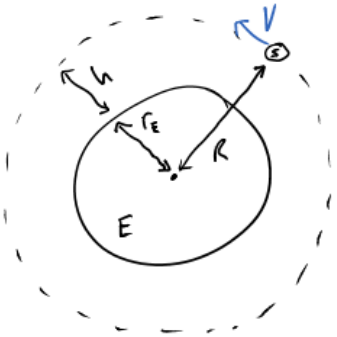
So, $|\Delta\vec{p}| = |\vec{J}| = 4.28\,\frac{kg\cdot m}{s}$, in $+\hat{y}$ direction

b.) $\Delta E = \Delta K + \Delta U^{0} = K_f - K_i = \frac{1}{2}m(v_f^2 - v_i^2) = -2.45\,J$

So 2.45 J lost

12. (8 points) Satellites that remain always above a certain location of the Earth are said to be in geosynchronous orbits. Use the following data to determine the height above the Earth's surface of one of these satellites located around the equator.

$G = 6.67 \times 10^{-11}\ N\cdot m^2/kg^2$, $M_{Earth} = 5.98 \times 10^{24}\ kg$, $R_{Earth} = 1.74 \times 10^{6}\ m$



FBD(s)

$\hat{r}$

$\vec{F}_{Es}^{G}$

$\Sigma F_r \Rightarrow \frac{G M_E M_s}{R^2} = \frac{M_s V^2}{R}$

$+\quad V^2 = \left[\frac{2\pi R}{T}\right]^2$

Combine

$R^3 = \frac{G M_E T^2}{4\pi^2}$

$R = 4.225 \times 10^7\ m$

$T = 24\ hr = 86{,}000\ s$

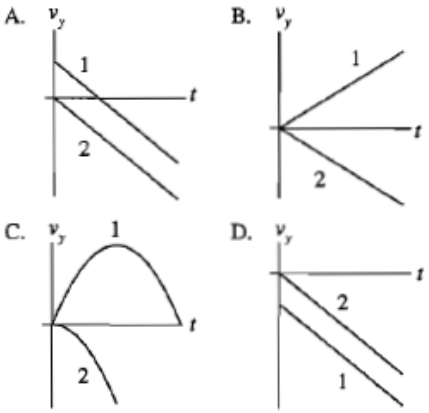
w/ $h + r_E = R$

$h = 4.05 \times 10^7\ m$

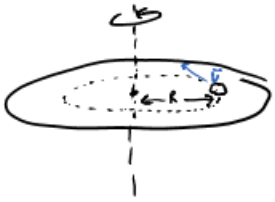
$\approx 40{,}000\ km$

13. (2 points) Ball 1 is thrown straight up in the air and, at the same instant, ball 2 is released from rest and allowed to fall. Which velocity graph represents the motion of the two balls?

A



14. (10 points) The coefficient of static friction between a small stone and a horizontal turntable is measured in the following way. The stone is placed on the turntable at a distance R from the rotational axis, and the speed of rotation is slowly increased until the stone complete 45 revolutions in one minute. When the experiment is repeated for several different values of R, it is found that the stone remains on the turntable if R < 26 cm, and that it slides off if R > 26 cm. Determine μ_s from these data.



$\Sigma F_y \Rightarrow F^N - mg = m\cancel{a_y}^{0}$

$F^N = mg$

$\Sigma F_r \Rightarrow F^{f,s} = m\frac{v^2}{R}$, @ R_{max}, $F^{f,s,max}$

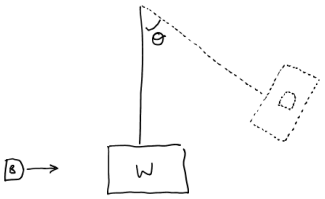
So, $\mu_s \cancel{(mg)} = \cancel{m}\frac{v^2}{R}$

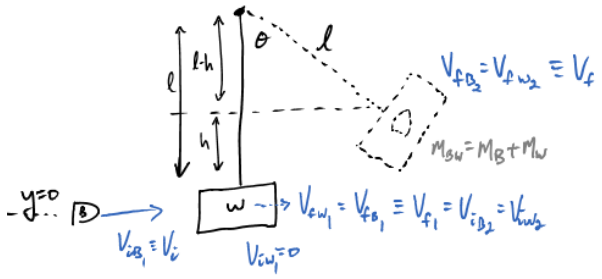
Speed

$|\vec{v}| = \frac{2\pi R n}{t}$, where n = # revolutions

$\Rightarrow \mu_s = \frac{4\pi^2 R^2 n^2}{g t^2}\frac{1}{R} = \boxed{0.589}$

15. (12 points) A simple way to measure the muzzle velocity of a gun is to fire a bullet directly into a wooden block that is suspended by a light string. By measuring the angle the block (with the bullet embedded in it) swings to, and knowing the physical characteristics of the apparatus, you can determine the speed with which the bullet left the gun. In one such experiment a 10 g bullet is fired into a 1.108 kg block of wood that is suspended by a meter-long piece of string. The wood and bullet then swing upward, subtending a maximum angle of 60°. What is the speed of the bullet right before it hits the wood?





Stage 1: collision

w/ $\Sigma \vec{F}_{ext_{BW}} = 0$, $\Sigma \vec{P}_i = \Sigma \vec{P}_f$

[1D] $M_B V_i + M_W \cancel{V_{iW_1}}^{0} = M_{BW} V_{f_1}$

$V_{f_1} = \frac{M_B}{M_{BW}} V_i$ (i)

Stage 2: swinging upward

geometry

$\cos\theta = \frac{l-h}{l}$

$h = l(1-\cos\theta) = y_{f_2}$ (ii)

$\Sigma E_i + \cancel{W_{nc}}^{0} = \Sigma E_f$

$\frac{1}{2} M_{BW} V_{f_1}^2 + M_{BW} g \cancel{y_{i_2}}^{0} = \frac{1}{2} M_{BW} \cancel{V_f}^{0} + M_{BW} g y_{f_2}$ (iii)

Combine (i), (ii), & (iii)

$V_i = \frac{M_B + M_W}{M_B} \sqrt{2gl(1-\cos\theta)} = \boxed{350 \text{ m/s}}$

Scores:

Problems

1	2-9	10	11	12	13	14	15

Exam Total
