Name:________________ ID:_______________ Lab (day/time)___________

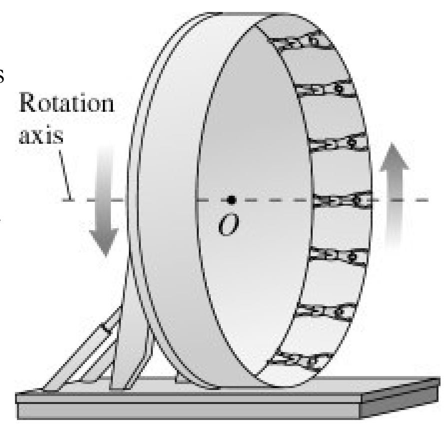
Physics 201

Final Exam

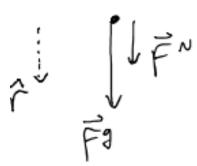
12/5/2017

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) In an amusement park ride, passengers stand inside an 8 m radius cylinder. Initially, the cylinder rotates with its axis oriented along the vertical. After the cylinder has acquired sufficient speed, it tilts into a vertical plane, that is, the axis tilts into the horizontal, as shown in the figure. Suppose that, once the axis has tilted into the horizontal, the ring rotates once every 4.5 s. If a rider's mass is 40 kg, with how much force does the ring push on her at the top of the ride?



FBD (top)



$$\sum F_r \Rightarrow \quad mg + F^N = m a_r \quad , \quad a_r = \frac{v^2}{r}$$

$$F^N = m\left(\frac{v^2}{r} - g\right) \quad , \quad v = \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{T}$$

$$F^N = m\left(\frac{4\pi^2 r}{T^2} - g\right) = 232\,N$$

Rubric

+1 pt – FBD

+2.5pt – $\sum F_r$

+1pt – $a_r = \frac{v^2}{r}$

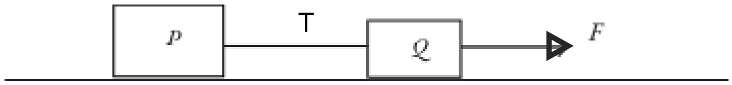
+1.5pts – $v = \frac{2\pi r}{T}$

+1.5pts – Algebra

+0.5pts – Answer w/ units

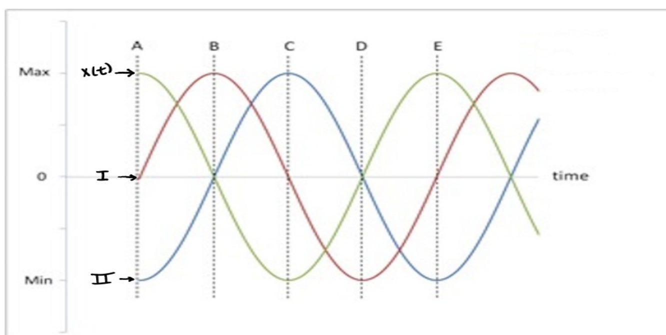
For questions 2 through 7 circle all correct answers, a given problem may have more than one correct answer. Each correctly circled answer will receive two points. There are **13** correct answers in this section and only the first **13** circled answers will be graded. There is no partial credit.

2. Two bodies P and Q on a frictionless horizontal surface are connected by a light cord. The mass of P is much greater than that of Q. A horizontal force (of magnitude F) is applied to Q as shown in the figure. Which one of the following statements regarding this situation are true?



[F] (a) The tension at T will always be greater than F.
[F] (b) The tension at T will only be greater than F if the blocks are moving to the right.
[F] (c) The tension at T will only be greater than F if the blocks are moving to the left.
[T] (d) The tension at T will always be less than F.
[F] (e) The tension at T will only be less than F if the blocks are moving to the right.
[F] (f) The tension at T will only be less than F if the blocks are moving to the left.

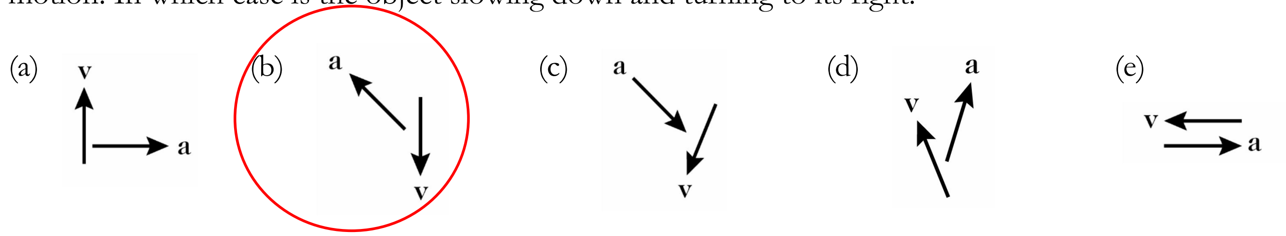
3. The figure shows several plots, one of which labeled as representing the position of a mass on a frictionless surface, connected to a horizontal spring that is vibrating back and forth. The other two plots are numbered I and II. Which of the following statements are true regarding these plots and this situation?



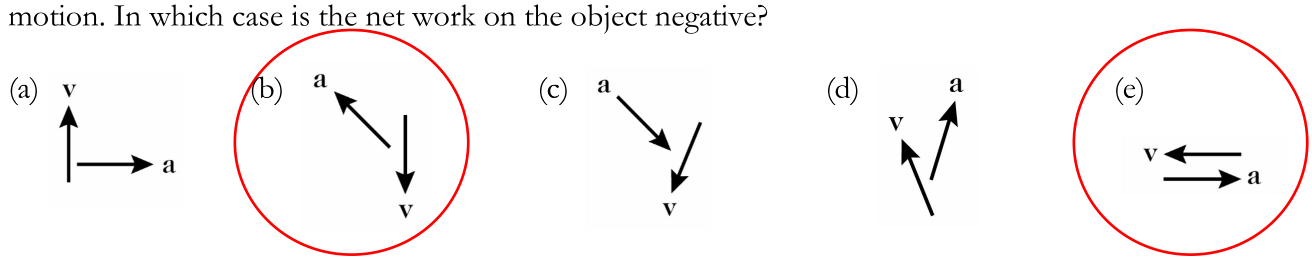
[F] (a) Plot I could represent the mass's velocity as a function of time.
[F] (b) Plot I could represent the mass's acceleration as a function of time.
[T] (c) Plot II could represent the mass's acceleration as a function of time.
[T] (d) The mass has the greatest amount of potential energy at points A, C, and E.
[F] (e) The mass has the greatest amount of kinetic energy at points A, C, and E.
[T] (f) The potential energy of the mass is maximum when its magnitude of acceleration is greatest.
[T] (g) The kinetic energy of the mass is greatest when its position is zero.

4. A light hydrogen molecule collides with a heavy water molecule, bouncing off each other. Which of the following statements are true regarding this situation.
[F] (a) The momentum change for the hydrogen molecule is smaller than the water molecule.
[F] (b) The momentum change for the hydrogen molecule is larger than the water molecule.
[T] (c) The momentum lost by one molecule is the same as the momentum gained by the other.
[F] (d) The impulse applied to the hydrogen molecule is greater than the impulse applied to the water.
[F] (e) The impulse applied to the hydrogen molecule is less than the impulse applied to the water.
[T] (f) The impulse applied to the hydrogen molecule is equal in magnitude to the impulse applied to the water.

5. Shown here are the velocity and acceleration vectors for an object in several different types of motion. In which case is the object slowing down and turning to its right?



6. Shown here are the velocity and acceleration vectors for an object in several different types of motion. In which case is the net work on the object negative?



7. A rock thrown with the same initial speed at an angle of 30° and 60° will hit the ground at the same location. Considering both the small and large angle cases, which of the following quantities are not the same during the time the projectile is in the air. Let the initial state be right after the rock has left the hand and the final be right before it hits the ground. Ignore air resistance.

[NS] (a) Time of flight
[S] (b) Change in position
[S] (c) Average acceleration
[S] (d) Displacement
[NS] (e) Max height
[NS] (f) Final velocity
[S] (g) Final speed

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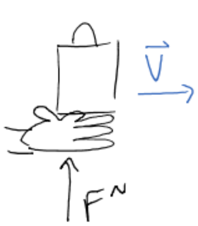
8. (4 points) You carry a 7.0 kg bag of groceries 1.2 m above the ground at constant velocity across a 2.3 m room. How much work do you do on the bag in the process? Explain your reasoning.



w/ $F^N \perp \vec{v}$ (and thus $\Delta\vec{r}$), $W=0$

also, if $W=\Delta K$ but $K=$ constant b/c $\vec{v}$ is constant

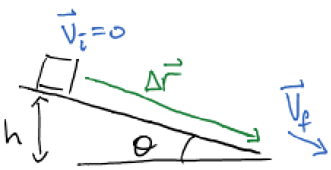
then $W=0$

Rubric

+ 2pts - answer

+ 2pts - reasoning

9. (4 points) A block slides down a frictionless inclined ramp. If the ramp makes an angle of 17.0° with respect to the horizontal, and the length of it is 30.0 m, find the speed of the block as it reaches the end of the ramp, assuming it started sliding from rest at the top.



$|\Delta\vec{r}| \equiv d$

w/out friction

$$\sum E_i + \sum W_{nc}^{\,0} = \sum E_f$$

$$U_i^g + K_i = U_f^g + K_f \Rightarrow \Delta U^g = -\Delta K$$

$$mgh = \frac{1}{2} m V_f^2$$

w/ $\sin\theta = \frac{h}{d}$, $V_f = \sqrt{2gd\sin\theta} = 13.11\,m/s$

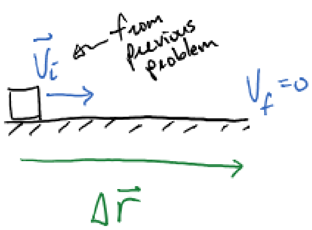
Rubric

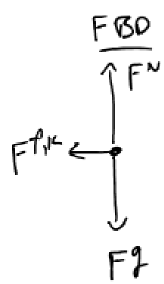
+2pts - Energy Analysis

+1pt - $h = d\sin\theta$

+1pt - Answer + units

10. (6 points) What the previous problem didn't tell you is that after the ramp, the block then slid another ten meters on a horizontal surface before coming to rest. What was the coefficient of kinetic friction between the block and the horizontal surface?





$$\sum E_i + W_{nc} = \sum E_f$$

$$K_i + W_{frict} = K_f^{\,0}$$

$$-\mu_k (mg)\Delta x = -\frac{1}{2} m V_i^2$$

$$\mu_k = \frac{V_i^2}{2g\Delta x} = 0.877$$

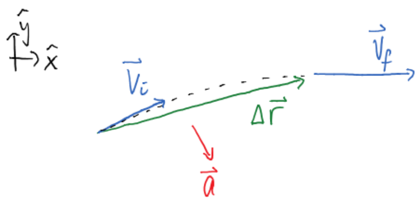
Rubric

+ 3pts - Energy Analysis

+ 2pts - $W_{friction}$

+ 1pt - Answer + units

11. (10 points) A 1000-kg spaceship is initially traveling with a velocity, v_i = <8, 12> m/s. It undergoes a constant net force, F_{net} = <4000, -2000> N. What is the (a) velocity and (b) displacement of the ship when it reaches its greatest y coordinate?



w/ $\Sigma\vec{F} = m\vec{a} \Rightarrow \vec{a} = \frac{\Sigma\vec{F}}{m} = \langle 4, -2 \rangle \, m/s^2$

	K	uk
x	$V_{ix} = 8\,m/s$, $a_x = 4\,m/s^2$	Δt, Δx, V_{fx}
y	$V_{iy} = 12\,m/s$, $a_y = -2\,m/s^2$, $V_{fy} = 0$	Δt, Δy

eq's

(i) $\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$

(ii) $V_f = V_i + a\Delta t$

(iii) $V_f^2 = V_i^2 + 2a\Delta x$

y-dir eq(ii)

$\cancel{V_{fy}}^{0} = V_{iy} + a_y \Delta t$

$\Delta t = -\frac{V_{iy}}{a_y} = 6\,s$

eq (i)

$\Delta y = V_{iy}\Delta t + \frac{1}{2} a_y \Delta t^2 = 36\,m$

x-dir eq(i)

$\Delta x = V_{ix}\Delta t + \frac{1}{2} a_x \Delta t^2 = 120\,m$

$V_{fx} = V_{ix} + a_x \Delta t = 32\,m/s$

$\vec{V}_f = \langle 32, 0 \rangle \, m/s$

$\Delta\vec{r} = \langle 120, 36 \rangle \, m$

Rubric

+ 2pts - finding $\vec{a} = \frac{\Sigma\vec{F}}{m}$
+ 2pts - physical rep + knowns/unknowns
+ 1pt - realizing @ max y, $V_y = 0$
+ 2pts - finding Δt
+ 2pts - finding $\vec{V}_f$ & $\Delta\vec{r}$ ← equations
+ 1pts - Answers + units ← #'s

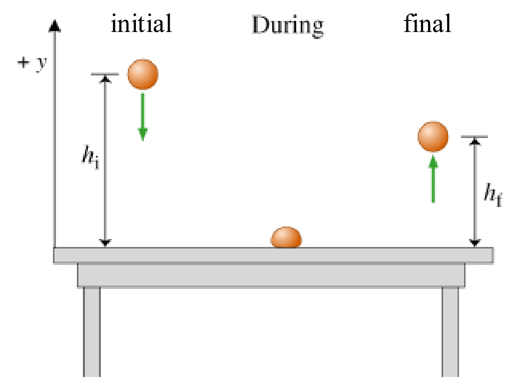
12. (10 points) A 100 g Superball is dropped from above a table and bounces to within 3 cm of its original height.

(a) Describe the energy transformations that occur during the time the ball is falling, interacting with the table, and raising back up to its final height.

(b) The initial gravitational potential energy is greater than the final. Where did this energy go?

(c) Calculate the Superball's loss of mechanical energy from the initial to final state.

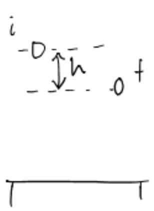
(d) Explain how you could estimate the average force the table puts on the Superball during the time they are interacting? You do not have to solve anything, just map out what physics you could use to determine this value.



(a) The ball starts with zero kinetic energy and maximum gravitational potential energy. As it falls towards the floor, gravitational potential energy is transformed into kinetic energy and thermal energy due to air resistance. While interacting with the table more of the kinetic energy of the ball is transformed into thermal energy in the ball and table. As it rises back up its kinetic energy decreases, transforming into gravitational potential energy and more thermal energy due to air resistance.

(b) Transformed into thermal energy that shows up as an increase in temperature in the ball, table, and surrounding air.

(c)



$$\sum E_i + \sum W_{nc} = \sum E_f$$

$$E_f - E_i = W_{nc}$$ ← Energy lost to $E_{thermal}$, $K_i = K_f = 0$

$$mg y_f - mg y_i = W_{nc}$$

$$mgh = \underline{0.294\ J}$$

(d) $\Delta p = \sum \bar{F}_{ext} \Delta t$

1) find $\Delta \vec{P}$ from right before hits table to right afterward by finding $\Delta \vec{v}$ in that same interval
2) Estimate time of interacting ~ 0.01 s
3) $\sum \vec{F}_{ext} = \vec{F}^g + \vec{F}^N$

use $\Delta \vec{P}$, Δt, + $F^g = mg$ to find $\vec{F}^N$

Rubric

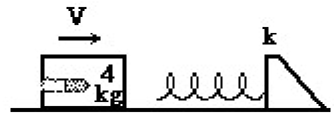
(a)
+ 3pts - energy transforms

(b)
+ 1pt - $\Delta U \rightarrow E^{th}$

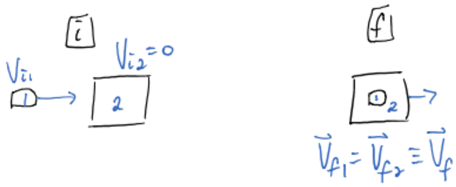
(c)
+ 2pts - Conservation of Energy application
+ 1pt - Answer + units

(d)
+ 3pts - describing how to find $\bar{F}$

13. (10 points) To measure the muzzle velocity of a gun a 10 g bullet is shot and embeds itself into a 4 kg block. The block is connected to a spring on a frictionless horizontal surface and the spring compresses 4.1 cm during the event. If the force constant of the spring is 2300 N/m, what was the velocity of the bullet when it entered the block?



Stage 1 (collision), during collision $\Sigma \vec{F}_{ext} = 0$, so $\Sigma \vec{P}_i = \Sigma \vec{P}_f$

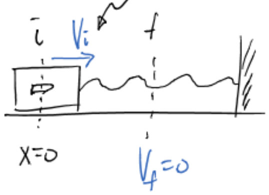


$$m_1 V_{i1} + m_2 V_{i2}^{\,0} = (m_1 + m_2) V_f$$

$$V_f = \frac{m_1}{(m_1+m_2)} V_{i1}$$

Stage 2 (Spring Compresses), $\Sigma E_i + \Sigma W_{nc}^{\,0} = \Sigma E_f$, $U^g = \text{constant}$

V_f from Stage 1



$$K_i + U_i^{s\,0} = K_f^{\,0} + U_f^s$$

$$\frac{1}{2}(m_1+m_2)V_i^2 = \frac{1}{2}k\Delta x_f^2$$

So, $$(m_1+m_2)\left[\frac{m_1}{(m_1+m_2)} V_{i1}\right]^2 = k\Delta x_f^2$$

$$V_{i1} = \frac{\Delta x}{m_1}\sqrt{k(m_1+m_2)} = 394\ \text{m/s}$$

Rubric

+2pts - Stage 1 is con. of $\vec{P}$

+2pts - application of $\Sigma \vec{P}_i = \Sigma \vec{P}_f$

+2pts - Stage 2 is con. of E

+2pts - application of $\Sigma E_i = \Sigma E_f$

+1.5pts - Combining 1 + 2

+0.5pts - Answer + units

extra space if needed

Scores:

Problems

1	2-7	8	9	10	11	12	13

Exam Total