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

Physics 201

Final Exam

12/07/2015

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) A child climbs the stairs to the top of a slide and then slides down the slide. Explain all of the energy transfers that occur during this activity and do consider friction. Where is work being done? Where, if any, does stored chemical potential energy come into play? Where are the various types of energy stored and where are they transferred to? Consider the system to include the child, the slide, and the Earth. Organize your answer so that it is not just a block of text, e.g. use headings.

→ Some E_{th} is lost

Climbing the slide: $U^{chem} \xrightarrow[\text{Work}]{\text{Via Internal}} U^g$

Stored chemical potential energy (food) is converted into potential energy of gravity. This is done by internal muscles in the child. During the process some non-conservative work in the muscles occurs, losing some of the energy to thermal energy - the muscles increase in temperature. The stairs do no work as they do not provide any force over a distance.

} 4pts

Sliding down the slide $U^g \longrightarrow K + E_{th}$

As the child slides down the slide, gravitational potential energy is converted into kinetic energy and non-conservative work from friction transfers some of that energy into thermal energy. The normal force from the slide does no work but the heat generated by friction warms both the slide and child.

} 4pts

For questions 2 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 **8** correct answers in this section and only the first **8** circled answers will be graded. There is no partial credit.

2. A light hydrogen molecule and a heavy water molecule collide, sending the hydrogen back in the opposite direction it was initially traveling, with no change to its speed. In regards to this collision, which of the following statements are *false*?

[F] (a) The change in momentum for the hydrogen molecule was zero.
[T] (b) The change in momentum for the water molecule was non-zero.
[T] (c) The momentum lost by one of the molecules is exactly the same as the momentum gained by the other.
[T] (d) The impulse on the hydrogen + water molecule system is zero.
[F] (e) Momentum is conserved for the water molecule.
[T] (f) Momentum is not conserved for the hydrogen molecule.

3. Joe and Bill throw identical balls vertically upward. Joe throws his ball with an initial speed of twice that of Bill's ball. Ignoring air resistance the maximum height of Joe's ball will be

[T] (a) four times that of Bill's ball.
[F] (b) two times that of Bill's ball.
[F] (c) equal to that of Bill's ball.
[F] (d) eight times that of Bill's ball.
[F] (e) roughly 1.4 times that of Bill's ball.

4. Consider Joe, Bill, and their balls from the previous problem. If Joe's ball is to go twice as high as Bill's, how much more must initial speed must Joe's ball have?

[F] (a) four times that of Bill's ball.
[F] (b) two times that of Bill's ball.
[F] (c) equal to that of Bill's ball.
[F] (d) eight times that of Bill's ball.
[T] (e) roughly 1.4 times that of Bill's ball.

5. Consider the flight of one of Joe or Bill's balls (previous problems) from it's maximum height until it reaches the ground. Which of the following statements are true.

[T] (a) The ball will gain an equal amount of momentum during the first half, time wise, as it will during the second half.
[F] (b) The ball will gain more momentum during the first half, time wise, as it will during the second half.
[F] (c) The ball will gain less momentum during the first half, time wise, as it will during the second half.
[F] (d) The ball will gain an equal amount of momentum during the first half, distance wise, as it will during the second half.
[T] (e) The ball will gain more momentum during the first half, distance wise, as it will during the second half.
[F] (f) The ball will gain less momentum during the first half, distance wise, as it will during the second half.

6. A simple pendulum swings back and forth. Which of the following statements are true?

[F] (a) When the pendulum is swinging from a low to high point, gravity is doing positive work.
[T] (b) When the pendulum is swinging from a high to low point, gravity is doing positive work.
[F] (c) When the pendulum is at it's lowest point gravity is doing the greatest magnitude work.
[F] (d) When the pendulum is at it's highest point, tension is doing the most positive work.
[F] (e) When the pendulum is at it' lowest point, tension is doing the most positive work.
[F] (f) Gravity does no work on the pendulum at any time.
[T] (g) Tension does no work on the pendulum at any time.

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7. (8 points) A steel ball is thrown in the air with a speed of 3.6 m/s at an angle of 70° from the horizontal. It drops on another steel ball of 1.4 times its mass resting on a sandy surface. If the original ball comes to a rest after the collision and the resting ball bounces, find the horizontal component of its velocity.

* During projectile motion $V_x = \text{const}$ b/c $a_x = 0$.

* During Collision, Considering both balls as the system

$$\sum P_{x_i} = \sum P_{x_f} \quad \text{b/c} \quad \sum F_x = 0 \quad , \quad M_2 = 1.4 M_1$$

So,

$$M_1 V_{1x_i} + M_2 \cancelto{0}{V_{2x_i}} = M_1 \cancelto{0}{V_{1x_f}} + M_2 V_{2x_f}$$

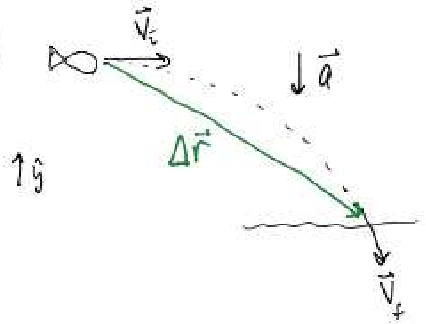
$$\cancel{M_1} |V| \cos\theta = 1.4 \cancel{M_1} V_{2xf}$$

$$\boxed{V_{2xf} = 0.879 \, m/s}$$

+2 Realizing Projectile Motion doesn't effect sol.
+2 Identifying Con. of. Mom. in x-dir.
+2 Application of $\sum P_{x_i} = \sum P_{x_f}$
+1 finding x-component of Vel.
+1 Answer w/ units.

8. (12 points) An eagle with a fish in its claws is flying horizontally at 6 m/s, 20 meters above the water. The eagle suddenly drops the fish. (a) What will be the fish's change in position vector from the time it is dropped to when it enters the water? (b) How much time passes from when the fish is dropped to when it's speed has doubled?

(a)



	K	UK	eqs
$\boxed{x}$	$V_{ix} = 6\,m/s = V_{fx}$ $a_x = 0$	Δt $\Delta x?$	(i) $\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$ (ii) $V_f = V_i + a\Delta t$ (iii) $V_f^2 = V_i^2 + 2a\Delta x$
$\boxed{y}$	$V_{iy} = 0\,m/s$ $a_y = -9.8\,m/s^2$ $\Delta y = -20m$	V_{fy} Δt	

$\boxed{y}$ (i) $\Delta y = \overset{0}{\cancel{V_{iy}}} \Delta t + \frac{1}{2} a_y \Delta t^2$

$$\Delta t = \sqrt{\frac{2\Delta y}{-g}} = 2.02s$$

$\boxed{x}$ $\Delta x = V_{ix} \Delta t + \frac{1}{2} \overset{0}{\cancel{a_x}} \Delta t^2$

$$= V_{ix} \sqrt{\frac{2\Delta y}{-g}} = 12.1\,m$$

So $\boxed{\Delta\vec{r} = \langle 12.1, -20 \rangle m}$

(b) $|\vec{V}_f| = \sqrt{V_{fx}^2 + V_{fy}^2}$, $|\vec{V}_f| = 2V_{ix}$, $V_{fy} = \overset{0}{\cancel{V_{iy}}} + a_y \Delta t$

So, $2V_{ix} = \sqrt{V_{ix}^2 + g^2 \Delta t^2}$, $\Delta t^2 = \frac{4V_{ix}^2 - V_{ix}^2}{g^2}$

$$\Delta t = \frac{\sqrt{3}\, V_{ix}}{g} = \boxed{1.06s}$$

Part (a) 7pts

+1 physical representation

+1 Knowns + Unknowns

+2 finding time

+2 finding Δx

+1 answering $\Delta\vec{r}$ as vector

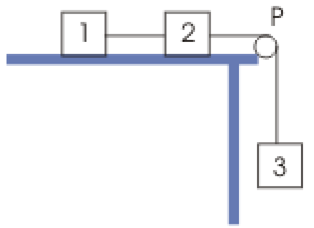
Part (b) 5pts

+2 $|\vec{V}_f| = \sqrt{V_{fx}^2 + V_{fy}^2}$

+2 V_{fy} eq.

+1 combining + solving

9. (10 points) Three masses are connected via light strings and the aid of an ideal pulley, as shown in the figure. The mass m_2 is twice as massive as m_1, while m_3 is three times as massive as m_1. Starting from rest, m_3 is released and falls 1.30 m to the floor. If the speed of m_3 right before it hits the floor is 3 m/s, what is the coefficient of kinetic friction between the table and the blocks? (hint: use an energy analysis)



$$\Sigma E_i + \Sigma W_{nc} = \Sigma E_f \quad , \quad m_1 \equiv m, \quad m_2 = 2m, \quad m_3 = 3m, \quad |\vec{V}_1| = |\vec{V}_2| = |\vec{V}_3| \equiv |\vec{V}|$$

$$\cancelto{0}{K_{1i}} + \cancelto{0}{K_{2i}} + \cancelto{0}{K_{3i}} + \cancel{U^g_{1i}} + \cancel{U^g_{2i}} + U^g_{3i} + W^f_1 + W^f_2 = K_{f_1} + K_{f_2} + K_{f_3} + \cancel{U^g_{1f}} + \cancel{U^g_{2f}} + \cancelto{0}{U^g_{3f}}$$

$$3\cancel{m}gh + \mu_k \cancel{m} g h \cos\cancelto{-1}{\theta_f} + \mu_k 2\cancel{m} g h \cos\cancelto{-1}{\theta_f} = \frac{1}{2}(\cancel{m}+2\cancel{m}+3\cancel{m})V_f^2$$

$$\cancel{3}gh - \cancel{3}\mu_k gh = \cancel{3}V_f^2$$

$$\mu_k = \frac{gh - V_f^2}{gh} = \boxed{0.294}$$

+3.5 Setting up Con. of. Energy w/ zeros + U^g cancelations

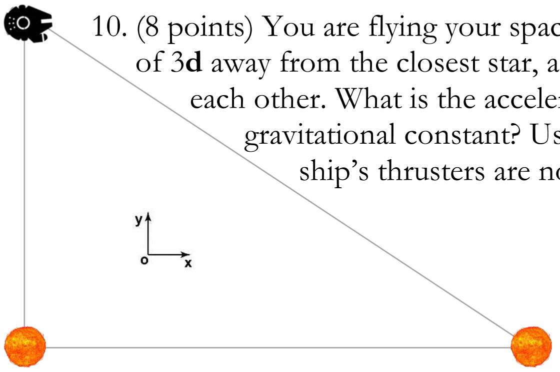
+3 quantifying work from friction

+1 dealing w/ masses + cancelation of m's

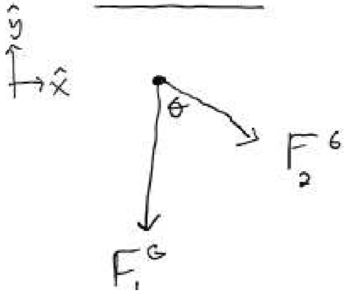
+1 $V_{f_1} = V_{f_2} = V_{f_3} \equiv V_f$

+1.5 Solving for μ_k + answer

10. (8 points) You are flying your spaceship past two stars, both with mass **M$_s$**. You are a distance of 3**d** away from the closest star, as oriented below. The stars are a distance of 4**d** away from each other. What is the acceleration of your ship in terms of **M$_s$**, **d**, and **G** the universal gravitational constant? Use the coordinate system shown in the figure and assume the ship's thrusters are not on.



FBD (ship)



$$\Sigma F_x \Rightarrow \frac{GM_s \cancel{m}}{25d^2}\sin\theta = \cancel{m}\, a_x$$

$$\Sigma F_y \Rightarrow -\frac{GM_s \cancel{m}}{9d^2} - \frac{GM_s \cancel{m}}{25d^2}\cos\theta = \cancel{m}\, a_y$$

geometry 3-4-5 triangle

$\tan\theta = \frac{4}{3}$, $\sin\theta = \frac{8}{10}$, $\cos\theta = \frac{6}{10}$

So $\vec{a} = \frac{GM_s}{d^2}\left\langle \frac{36}{1125}, -\frac{152}{1125} \right\rangle$

+1 FBD

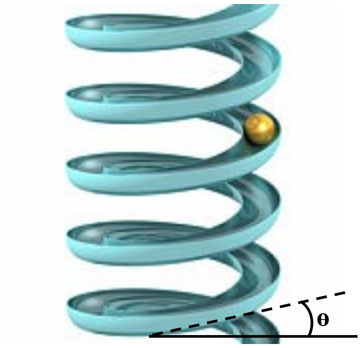
+2 $\Sigma F_x + \Sigma F_y$

+2 $|F^G|$

+2 Vector Components / geometry

+1 answer

11. (12 points) A ball enters a frictionless track spiraling upward with a speed v_o. The radius of the track is half a meter and it has a pitch (θ) of 15°. (a) If the initial speed of the ball is 12 m/s, how high vertically will it rise. (b) Compare your answer to part (a) with the height the ball would rise if it had been thrown vertically upward, into free-fall, with the same initial speed. Explain your results. (c) If you wish the ball to make exactly 5 revolutions before momentarily coming to rest, how fast must it initially be moving when entering the spiral track?

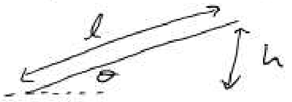


a) $\Sigma E_i + \Sigma \cancel{W_{nc}}^{0} = \Sigma E_f$

$\frac{1}{2}\cancel{m} V_i^2 = \cancel{m} g h$, $\boxed{h = 7.35 m}$

b) same answer as (a) b/c both have zero non-conservative work

c) Imagine stretching it out straight



$l \approx N(2\pi r)$, w/ $N = 5$

but actually $l = \frac{N(2\pi r)}{\cos\theta}$ to account for pitch

& $\sin\theta = \frac{h}{l}$ => $\frac{1}{2}\cancel{m} V_i^2 = mgh$

$= \cancel{m} g N(2\pi r)\tan\theta$

& $\boxed{V_i = 9.08 m/s}$

Part (a) 5 pts

+2 Identifying Con. of. Energy.

+2 apply " " "

+1 Answer w/ units

Part (b) 2pts

Part (c) 5pts

+2 $l \approx N(2\pi r)$

+0.5 accounting for pitch

+1 finding h

+1 Con. of. Energy.

+0.5 Answer (allow answer that ignores pitch)

Scores:

Problems

1	2-6	7	8	9	10	11

Exam Total
