Physics 141, Midterm Exam #1

Thursday October 3, 2013

8.00 am – 9.30 am

Do not turn the pages of the exam until you are instructed to do so.

Exam rules: You may use *only* a writing instrument while taking this test. You may *not* consult any calculators, computers, books, nor each other.

1. Answer the multiple-choice questions (problems 1 – 10) by marking your answer on the scantron form. For each multiple-choice question (problems 1 – 10), select only one answer. Questions with more than one answer selected will be considered incorrect. **If your student ID is not listed properly on the Scantron form (in the bubbles on the top-left corner), the form will not be processed and you loose points for all multiple-choice questions.**
2. Problems 11, 12, and 13 must be answered in the blue exam booklets **(answer questions 11 and 12 in booklet 1 and question 13 in booklet 2.)** The answers need to be well motivated and expressed in terms of the variables used in the problem. You will receive partial credit where appropriate, but only when we can read your solution. Answers that are not motivated will not receive any credit, even if correct.

At the end of the exam, you need to hand in your exam, the blue exam booklets, and the scantron form. All items must be clearly labeled with your name, your student ID number, and the day/time of your recitation. **If any of these items are missing, we will not grade your exam, and you will receive a score of 0 points.**

Name: _____

ID number: _____

Recitation Day/Time: _____

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Useful Relations:

$$\cos(30°)=\frac{1}{2}\sqrt{3} \quad \sin(30°)=\frac{1}{2} \quad \tan(30°)=\frac{1}{3}\sqrt{3}$$
$$\cos(45°)=\frac{1}{2}\sqrt{2} \quad \sin(45°)=\frac{1}{2}\sqrt{2} \quad \tan(45°)=1$$
$$\cos(60°)=\frac{1}{2} \quad \sin(60°)=\frac{1}{2}\sqrt{3} \quad \tan(60°)=\sqrt{3}$$

$$\cos\left(\frac{1}{2}\pi-\theta\right)=\sin(\theta) \quad \sin\left(\frac{1}{2}\pi-\theta\right)=\cos(\theta)$$
$$\cos(2\theta)=1-2\sin^2(\theta) \quad \sin(2\theta)=2\sin(\theta)\cos(\theta)$$

	Circle	Sphere
circumference	$2\pi r$	
(surface) area	πr^2	$4\pi r^2$
volume		$\frac{4}{3}\pi r^3$

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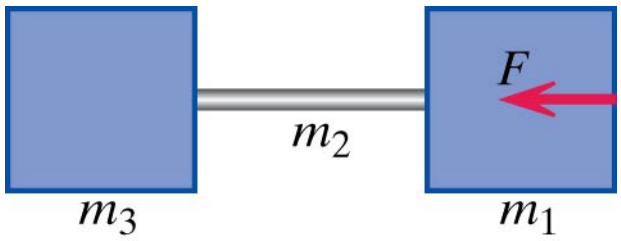
Problem 1 (2.5 points)

Two blocks of mass m_1 and m_3, connected by a rod of mass m_2, are sitting on a frictionless surface. You push to the left on the right block with a constant force F.



What is the compression force in the rod near its right end?

1. $m_1F/(m_1 + m_2 + m_3)$
2. $m_2F/(m_1 + m_2 + m_3)$
3. $m_3F/(m_1 + m_2 + m_3)$
4. $(m_1 + m_2)F/m_1$
5. $(m_1 + m_3)F/m_2$
6. $(m_2 + m_3)F/m_3$
7. $(m_1 + m_2)F/(m_1 + m_2 + m_3)$
8. $(m_1 + m_3)F/(m_1 + m_2 + m_3)$
9. $(m_2 + m_3)F/(m_1 + m_2 + m_3)$

Problem 2 (2.5 points)

The z-component of the linear momentum of a ball is observed to change with time in the following way:

At $t = 0$ s, $p_z = 12$ kg m/s

At $t = 1$ s, $p_z = 7$ kg m/s

At $t = 2$ s, $p_z = 2$ kg m/s

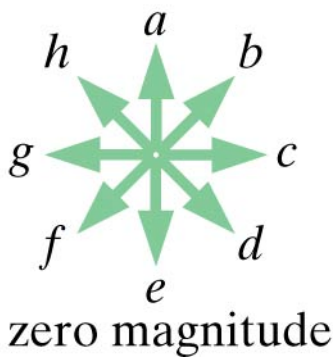
At $t = 3$ s, $p_z = -3$ kg m/s

Which of the following statements about the z component of the net force acting on the ball during the time the ball is observed is true?

1. The z component of the net force on the ball is zero.
2. The z component of the net force on the ball is constant.
3. The z component of the net force on the ball is decreasing with time.
4. The z component of the net force on the ball is increasing with time.
5. Not enough information is given to determine the z component of the net force on the ball.

Problem 3 (2.5 points)

A ball moves in the direction of the arrow labeled *c* in the Figure below.



The ball is truck by a stick that briefly exerts a force on the ball in the direction of the arrow labeled *e*. Which arrow best describes the direction of $\Delta\vec{p}$, the change in the ball's linear momentum?

1. *a*
2. *b*
3. *c*
4. *d*
5. *e*
6. *f*
7. *g*
8. *h*
9. *j*

Problem 4 (2.5 points)

Which fundamental interaction (gravitational, electromagnetic, strong, or weak) is responsible for each of the following processes:

a) A neutron outside a nucleus decays into a proton, electron, and antineutrino.

b) Protons and neutrons attract each other in a nucleus.

c) The Earth pulls on the Moon.

d) Protons in a nucleus repel each other.

1. (a) Gravitational, (b) Electromagnetic, (c) Strong, and (d) Weak.
2. (a) Electromagnetic, (b) Gravitational, (c) Strong, and (d) Weak.
3. (a) Gravitational, (b) Electromagnetic, (c) Weak, and (d) Strong.
4. (a) Strong, (b) Electromagnetic, (c) Gravitational, and (d) Weak.
5. (a) Electromagnetic, (b) Strong, (c) Gravitational, and (d) Weak.
6. (a) Weak, (b) Strong, (c) Gravitational, and (d) Electromagnetic.
7. (a) Weak, (b) Electromagnetic, (c) Gravitational, and (d) Strong.
8. (a) Strong, (b) Weak, (c) Gravitational, and (d) Electromagnetic.

Problem 5 (2.5 points)

In the last 19 years, how many times did the Yankees miss the post season?

1. 0 times.
2. 1 time.
3. 2 times.
4. 3 times.
5. 4 times.
6. 5 times.
7. 6 times.
8. 12 times.
9. 19 times.

Problem 6 (2.5 points)

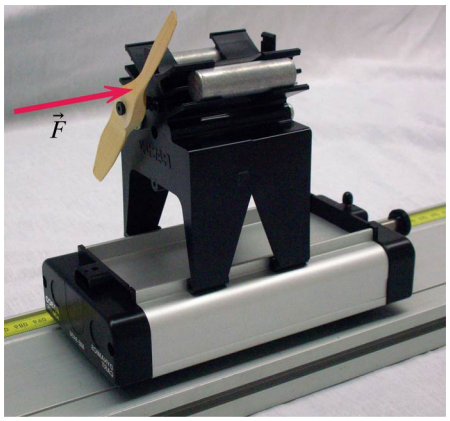
Which of the following statements is **not** correct?

1. The momentum principle tells us that $\Delta\vec{p} = \vec{F}_{net}\Delta t$.
2. The principle of relativity states that physical laws work in the same way for observers in uniform motion as for observers at rest.
3. The momentum principle tells us that $\Delta\vec{v} = \vec{a}_{net}\Delta t$.
4. The velocity of an object is related to its momentum in the following manner

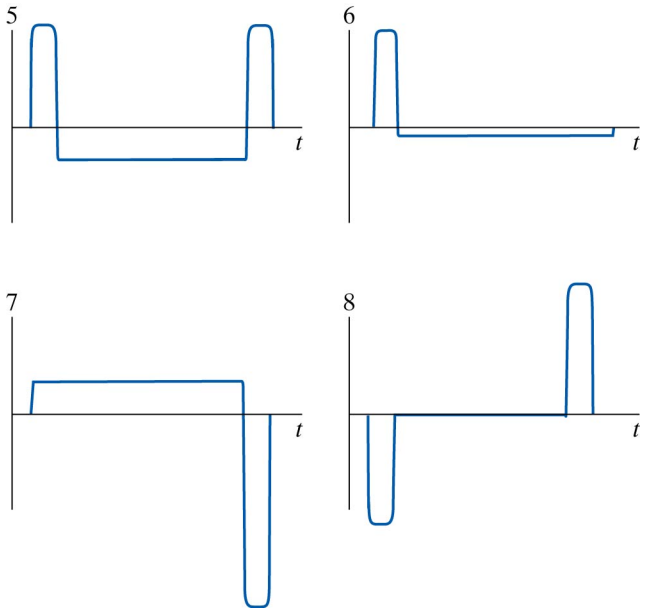
$$\vec{v} = \frac{\vec{p}/m}{\sqrt{1+\left(\frac{p}{mc}\right)^2}}$$

Problem 7 (2.5 points)

A cart rolls on a frictionless track. A fan is mounted on the cart, and when the fan is turned on, a constant force is acting on the cart. The fan is turned on and you hold the cart stationary. You then take your hand away and the cart moves forward, in the $+x$ direction. After travelling a long distance along the track, you quickly stop and hold the cart.



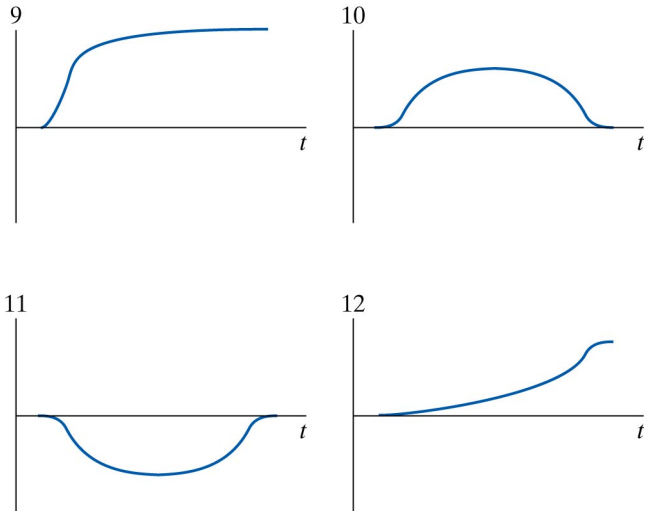
a. The following four graphs display the x component of the net force acting on the cart as function of time. Which of these graphs matches the motion we just described?



PROBLEM CONTINUED ON NEXT PAGE

Problem 7 (continued)

b. The following four graphs display the position of the cart along the track as function of time. Which of these graphs matches the motion we just described?

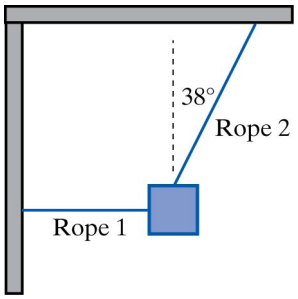


Select one of the answer combinations listed below.

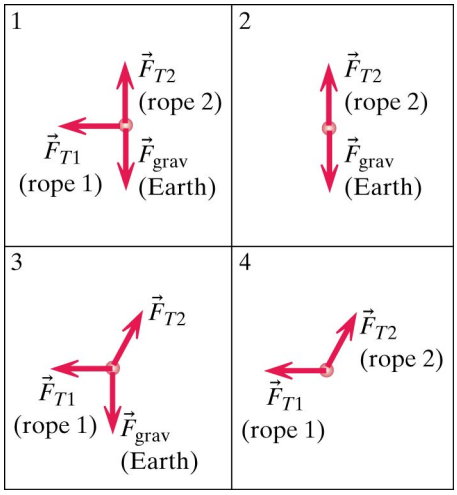
1. Answer question a: Graph 5; Answer question b: Graph 9.
2. Answer question a: Graph 5; Answer question b: Graph 10.
3. Answer question a: Graph 5; Answer question b: Graph 12.
4. Answer question a: Graph 6; Answer question b: Graph 9.
5. Answer question a: Graph 6; Answer question b: Graph 10.
6. Answer question a: Graph 6; Answer question b: Graph 12.
7. Answer question a: Graph 7; Answer question b: Graph 9.
8. Answer question a: Graph 7; Answer question b: Graph 12.
9. Answer question a: Graph 8; Answer question b: Graph 9.
10. Answer question a: Graph 8; Answer question b: Graph 10.

Problem 8 (2.5 points)

A box hangs motionless from two ropes, as shown in the Figure below.



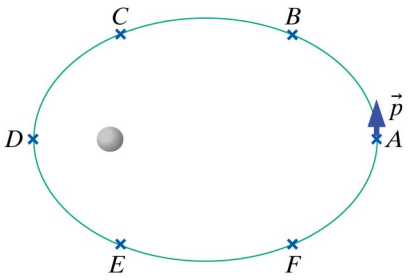
Which of the free-body diagrams shown in the Figure below correctly describes the forces acting on the box?



1. Diagram 1
2. Diagram 2
3. Diagram 3
4. Diagram 4

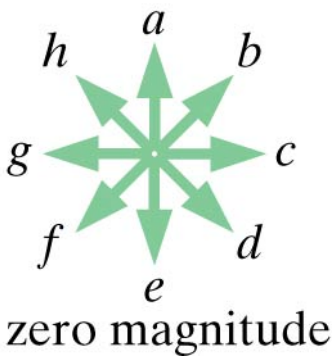
Problem 9 (2.5 points)

A comet orbits a star in an elliptical orbit, as shown in the Figure below. The linear momentum of the comet at location *A* is shown in the Figure.



What is the direction of the change in the linear momentum of the comet when it is located at location *C*?

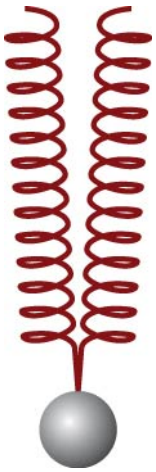
1. Direction *a*
2. Direction *b*
3. Direction *c*
4. Direction *d*
5. Direction *e*
6. Direction *f*
7. Direction *g*
8. Direction *h*
9. Direction *j*



Problem 10 (2.5 points)

You have two identical springs. When you hang a mass m from one of the springs, the system oscillates with a period T.

Now you connect the two springs in parallel to mass m, as shown in the Figure below.

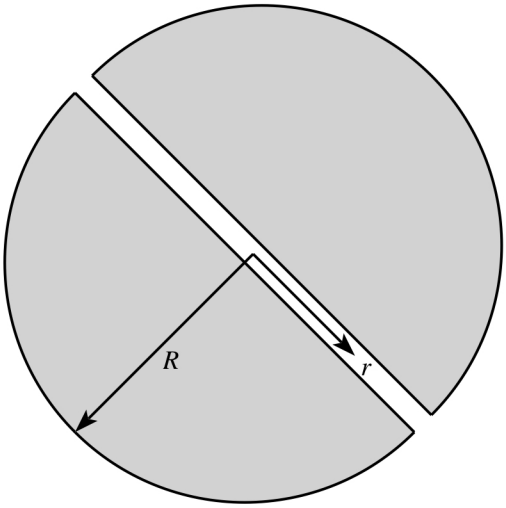


What will be the period of the mass now?

1. $4\,T$
2. $2\,T$
3. $\sqrt{2}\,T$
4. T
5. $T/\sqrt{2}$
6. $T/2$
7. $T/4$

Problem 11 (25 points)

Consider the Earth to be a sphere of radius R and uniform density ρ. Suppose that a hole is drilled along the diameter of the Earth, straight through the center. After the hole is drilled, the air is pumped out of it.



Consider a mass m dropped into the hole.

a. What is the magnitude of the net force exerted by the Earth on mass m when it is located a distance r from the center of the Earth? Take $r < R$.

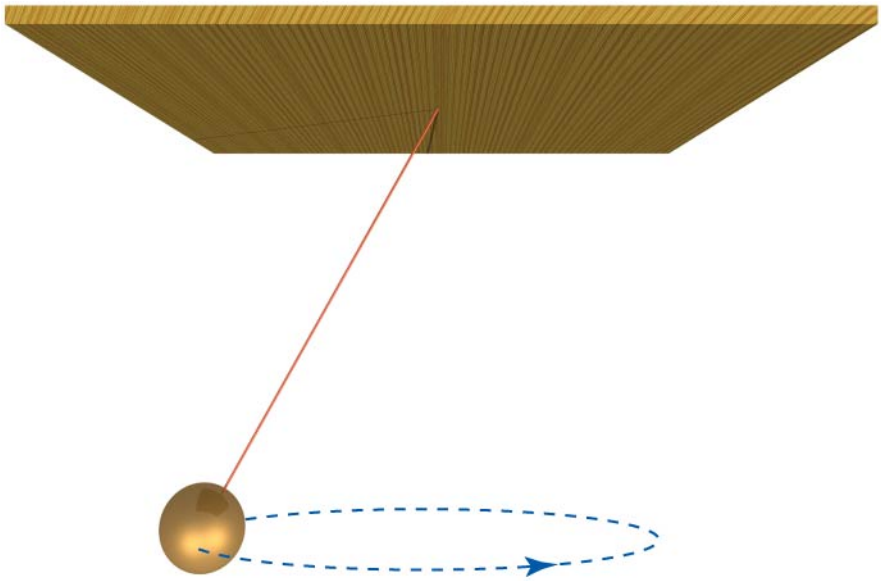
b. What type of motion will result from this type of force?

c. How long will it take until mass m reaches the center of the Earth?

Express all your answers in terms of the variables provided. Your answers must be well motivated.

Problem 12 (25 points)

A ball of mass m is suspended from a string, and after given a push, moves along a horizontal circular path, as shown in the Figure below.

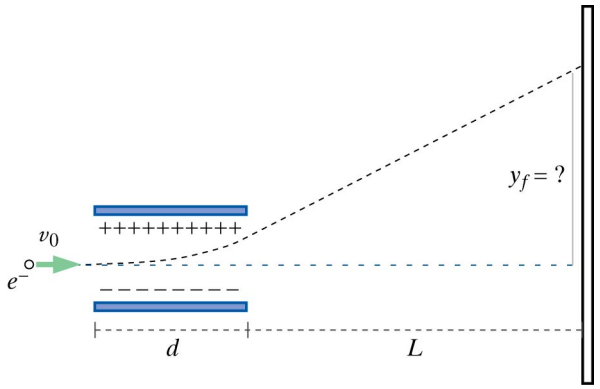


You measure the length of the string to be L and the angle between the string and the vertical axis to be θ. You also time the motion and find that it takes T seconds for the ball to make one complete circular trip. From these measurements determine the gravitational constant g. You can ignore the mass of the string in your calculations.

Express all your answers in terms of the variables provided. Your answers must be well motivated.

Problem 13 (25 points)

In a cathode ray tube (CRT) used in older television sets, a beam of electrons is steered to different places on a phosphor screen, which glows at the locations hit by the electrons. The CRT is evacuated, so there are few gas molecules present for the electrons to run into. Electric forces are used to accelerate electrons of mass m to a speed v_0, small compared to the speed of light, after which they pass between positively and negatively charged metal plates that deflect the electron in the vertical direction (upward in the Figure below, or downward if the sign on the charges on the plates is reversed).



While the electron is between the plates, it experiences a uniform vertical force F, but when the electron is outside the plates, there is negligibly force acting on it. The gravitational force on the electron is negligible small compared to the electric force in this situation. The length of the metal plates is d, and the phosphor screen is a distance L from the metal plates. Where does the electron hit the screen? That is, what is y_f?

Express all your answers in terms of the variables provided. Your answers must be well motivated.

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