Physics 141, Midterm Exam #1

Thursday September 29, 2016

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 bottom-left corner), the form will not be processed and you lose 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.**

You are required to complete the following *Honor Pledge for Exams*. Copy and sign the pledge before starting your exam.

"I affirm that I will not give or receive any unauthorized help on this exam, and that all work will be my own."

_____

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Name: _____

Signature: _____

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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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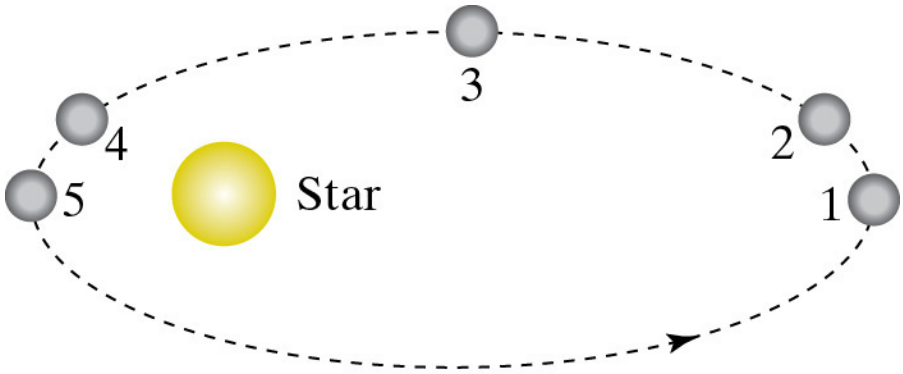
Problem 1 (2.5 points)

Which is the color of the shirts of the best national soccer team in the world (according to your teacher)?

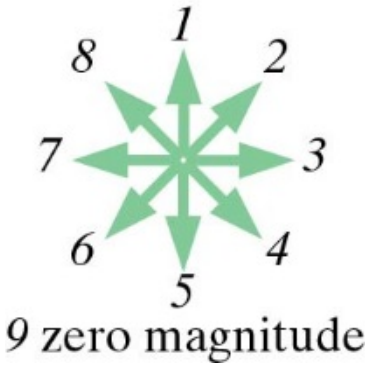
1. Black
2. Green
3. Blue
4. Red
5. Orange
6. Yellow
7. Brown
8. White
9. Soccer, what is that?

Problem 2 (2.5 points)

A comet travels in an elliptical path around a star in the direction shown in the figure below.

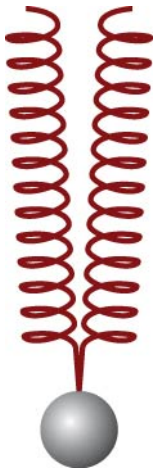


What is the direction of $\Delta\vec{p}$, the change in the comets linear momentum, when it is located at location 1?



Problem 3 (2.5 points)

You have two identical springs, connected in parallel. When you hang a mass *m* from this system, as shown in the figure below, the new equilibrium position of the system is a distance *d* below the equilibrium position when no mass is connected to the system.

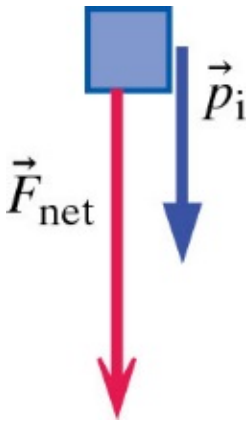


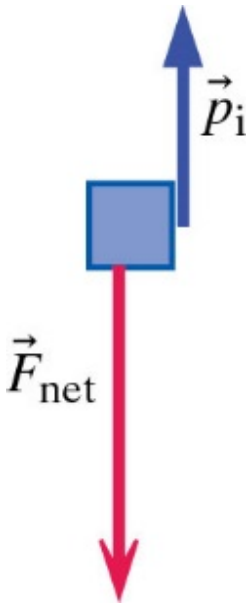
Now you connect the two springs in series. The system is in equilibrium when you connect mass *m* to the end of the lower spring. What is the displacement of mass *m* when it has reached its new equilibrium position?

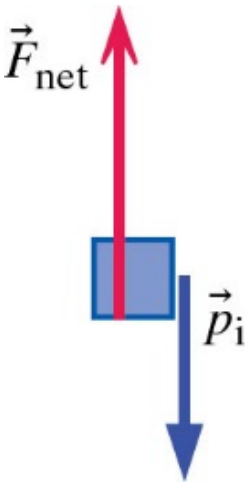
1. 4 *d*
2. 2 *d*
3. $\sqrt{2}\,d$
4. *d*
5. $d/\sqrt{2}$
6. $d/2$
7. $d/4$

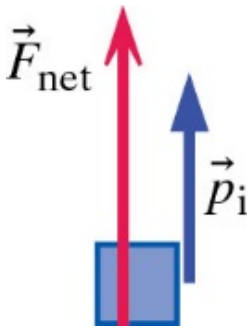
Problem 4 (2.5 points)

A block is attached to a standing spring and is oscillating up and down. Which diagram shows the direction of $\vec{F}_{\text{net}}$ and $\vec{p}$ just before the block reaches its highest point?

1. 

2. 

3. 

4. 

5. None of these

Problem 5 (2.5 points)

Two wires are made of the same kind of metal.

- Wire A has a diameter d and length L. You hang a mass M from wire A and measure the amount of stretch ΔL_A. You use this information to determine its Young's modulus Y_A.
- Wire B, which is made of the same material as wire A, has a diameter $2d$ and length L. You hang the same mass M from wire B and measure the amount of stretch ΔL_B. You use this information to determine its Young's modulus Y_B.

Which of the following statements is correct?

1. $Y_B = Y_A$.
2. $Y_B > Y_A$.
3. $Y_B < Y_A$.

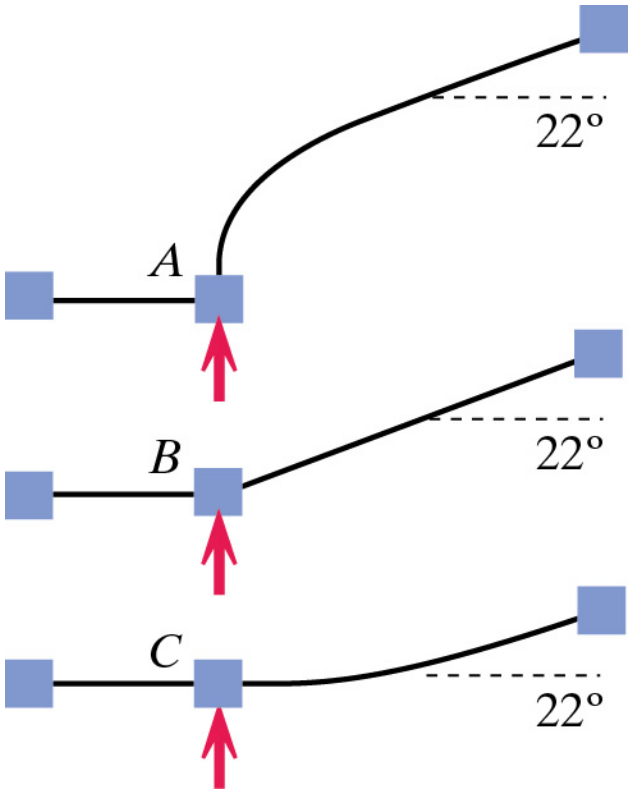
Problem 6 (2.5 points)

You hold a tennis ball at rest above your head, then open your hand and release the ball, which begins to fall. In the next 0.1 s, which of the following statements about the linear momentum change is true?

1. $\left|\Delta\vec{p}_{\text{Earth}}\right| < \left|\Delta\vec{p}_{\text{ball}}\right|$
2. $\left|\Delta\vec{p}_{\text{Earth}}\right| > \left|\Delta\vec{p}_{\text{ball}}\right|$
3. $\left|\Delta\vec{p}_{\text{Earth}}\right| = \left|\Delta\vec{p}_{\text{ball}}\right|$

Problem 7 (2.5 points)

A 0.7 kg block of ice is sliding by you on a very slippery floor with an initial velocity of 2.5 m/s. As it goes by, you give it a kick perpendicular to its path. Your foot is in contact with the ice block for 0.003 s. The block eventually slides at an angle of 22° from its original direction. The overhead view, shown in the figure below, is approximately to scale. The arrow represents the average force your toe applies to the block of ice.

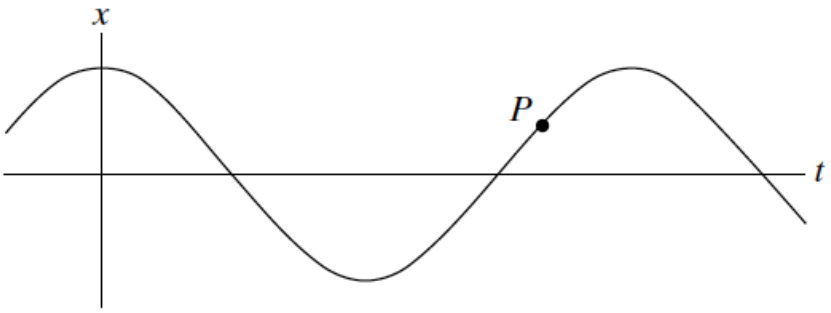


Which of the possible paths shown in the diagram corresponds to the correct overhead view of the block's path?

1. Diagram A
2. Diagram B
3. Diagram C

Problem 8 (2.5 points)

A mass attached to a spring oscillates back and forth as indicated in the position vs. time plot below.



At point *P*, the mass has

1. positive velocity and positive acceleration.
2. positive velocity and negative acceleration.
3. positive velocity and zero acceleration.
4. negative velocity and positive acceleration.
5. negative velocity and negative acceleration.
6. negative velocity and zero acceleration.
7. zero velocity but is accelerating with a positive or negative acceleration.
8. zero velocity and zero acceleration.

Problem 9 (2.5 points)

Figure 9.1 shows two positively charged objects and one negatively charged object. The magnitude of the charge on each object is the same.

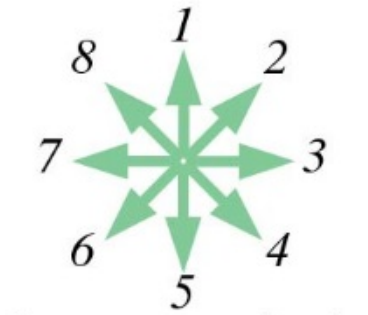
Figure 9.1.

Figure 9.2 shows one positively charged objects and two negatively charged objects. The magnitude of the charge on each object is the same.

Figure 9.2.

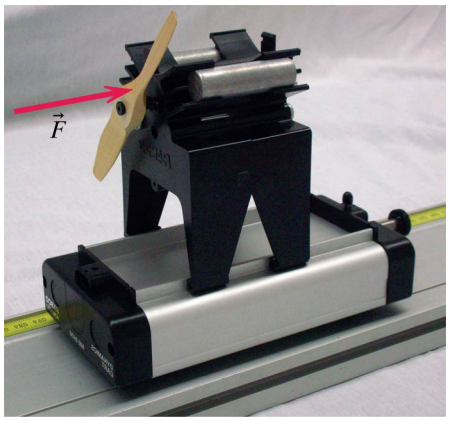
What is the direction of the net force acting on the negative charge shown in Figure 9.1 and what is the direction of the net force acting on the positive charge shown in Figure 9.2?

1. Figure 9.1: 7 Figure 9.2: 7
2. Figure 9.1: 1 Figure 9.2: 7
3. Figure 9.1: 3 Figure 9.2: 7
4. Figure 9.1: 5 Figure 9.2: 7
5. Figure 9.1: 9 Figure 9.2: 7
6. Figure 9.1: 7 Figure 9.2: 3
7. Figure 9.1: 1 Figure 9.2: 3
8. Figure 9.1: 3 Figure 9.2: 3
9. Figure 9.1: 5 Figure 9.2: 3
10. Figure 9.1: 9 Figure 9.2: 3

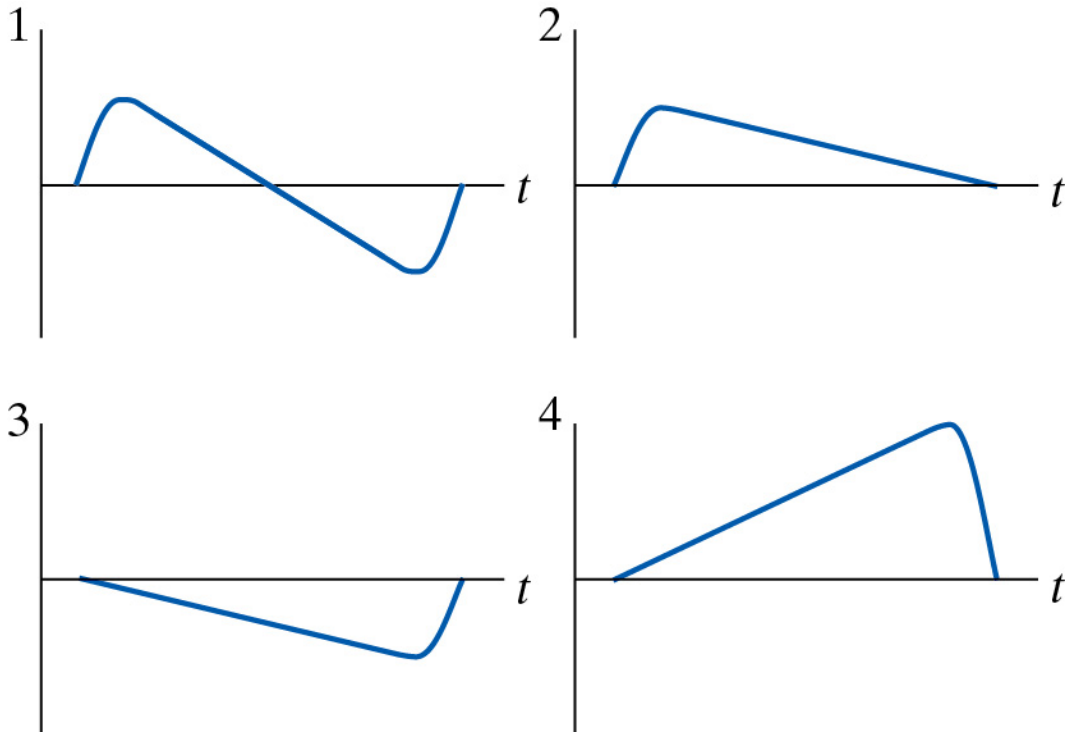


Problem 10 (2.5 points)

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.

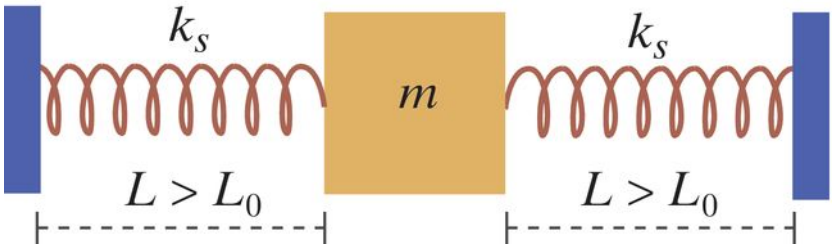


Which of the following four graphs, showing the linear momentum of the cart along the track (vertical axis) versus time (horizontal axis), matches the experiment just described.



Problem 11 (25 points)

An object of mass m rests on a frictionless surface and is attached by two stretched springs (stiffness k_s and rest length L_0) to rigid walls, as shown in the Figure below.



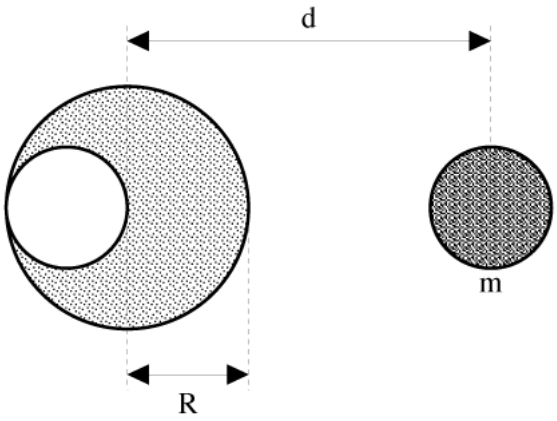
The springs are initially stretched by an amount (L - L_0). When the object is displaced to the right and released it oscillates horizontally.

a. Draw a force diagram, indicating all the forces acting on the object in the horizontal direction when the object is released.
b. What is the net force acting on the mass when the object is displaced by a distance x to the right?
c. What is the period of the motion?
d. If the springs were replaced with springs with a shorter rest length so that the springs are initially stretched more, would the period be larger, smaller, or the same? Your answer should be well motivated.

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

Problem 12 (25 points)

A spherical hollow is made in a sphere of radius R such that its surface touches the outside surface of the sphere and passes through its center (see Figure below). The mass of the sphere before hollowing was M. What is the magnitude of the gravitational force between the hollowed-out sphere and a small sphere of mass m, located a distance d from the center of the hollowed-out sphere?



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

Problem 13 (25 points)

You hold a small metal ball of mass m a height h above the floor. You let the ball go and it falls to the floor. Choose the origin of your coordinate system to be on the floor where the ball hits. Choose the y axis to be the vertical axis and assume the positive y axis is the vertical axis above the floor.

a. What is the velocity v_f of the ball just before the ball hits the floor? Note: make sure you specify the direction of the velocity.

Assume that the ball bounces elastically such that just after hitting the floor, the ball moves upwards with a speed equal to the speed just before it hits the floor.

b. Calculate the time required for the ball to travel from the floor to its original height and back to the floor.
c. What is the average force that the ball exerts on the floor as it bounces up and down?

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

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