Phys 172 Exam 1, 2010 fall, Purdue University

<u>What to bring:</u>
1. Your student ID – we will check it!
2. Calculator: any calculator as long as it does not have internet/phone connection
3. Pencils

- Exam will take place in Elliot Hall of Music.
- When entering hall, please take a writing board (available at the entrance).
- Please prepare to be seated in "exam formation" – each other row and each other seat.
- Turn off your phone and keep it in your bag/pocket at all times
- Equation sheet is provided at the end of the exam. You can tear it off and use, you do not have to return it.
- At the end of the exam please turn in your scantron sheet <u>and</u> paper exam to one of the TAs (don't forget to sign your paper exam at the right-top corner).

DO NOT OPEN YOUR EXAM UNTIL TOLD

Practice Exam I, Phys 172, Spring 2010

EXAM # 05

*1. Record your two-digit exam version number on **scantron** form in the field "Test/Quiz number". Please do not omit leading zero.*

*2. Write your name in <u>the top-right corner</u> here and on the **scantron** form*

*3. Record your PUID number in the respective field on your **scantron** form*

Do not use other paper. Write on the back of this test if needed.

The page with major equations is provided with this exam (in the back)

*Circle your answers here and on **scantron** form. At the end of the exam, you will return **scantron** form and this printout with circled answers to your TA.*

Problems 1-3

For the next four problems consider vectors in the diagram shown below, in which each division is equal to 1 m.
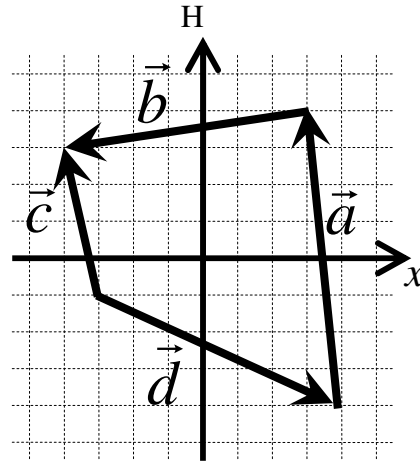
Problem 1 (5 pts)

What are the components of the vector $\vec{a}$?

A) <8, -1> m
B) <9, 2> m
C) <-1, 8> m
D) <3, 4> m
E) <4, 3> m

Problem 2 (5 pts)

What is the magnitude of the vector $\vec{a}$?

A) 8.06 m
B) 9 m
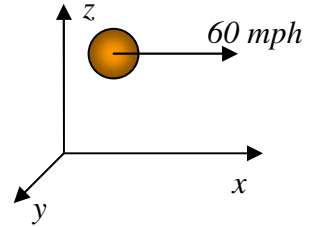C) 8.21 m
D) 8.32 m
E) 5 m

Problem 3 (5 pts)

Which one of the following statements is true about vectors $\vec{a}$, $\vec{b}$, $\vec{c}$ and $\vec{d}$?

A) $\vec{a} + \vec{b} + \vec{c} + \vec{d} = 0$
B) $\vec{a} + \vec{b} = \vec{c} - \vec{d}$
C) $\vec{a} + \vec{c} = \vec{b}$
D) $\vec{a} = \vec{c} + \vec{b}$
E) $\vec{a} - \vec{b} = \vec{c}$

Problems 4-5

A tennis ball of mass 57 g is served in horizontal direction
along *x*-axis and initially flies at speed 60 mph.

Problem 4 (5 pts)

What is the initial magnitude of its momentum?

A) 3420 kg·m/s
B) 1.5 kg·m/s
C) 1500 kg·m/s
D) 3.42 kg·m/s
E) 22.1 kg·m/s

Problem 5 (5 pts)

What is the magnitude of the *x*-component of this tennis ball after 1 second?
(gravitational force on the ball is downwards in -*z* direction)

A) 2.1 kg·m/s
B) 3420 kg·m/s
C) 1.5 kg·m/s
D) 3900 kg·m/s
E) 22.1 kg·m/s

Problem 6 (5 pts)
An electron was accelerated to from a speed $0.9999c$, to $0.99999c$ in 1 second ($c=3\times10^8$ m/s is the speed of light). What was the average force applied to an electron during that second? Assume unidirectional motion. Mass of an electron is 9×10^{-31} kg.

A) 4.1×10^{-20} N
B) 2.4×10^{-26} N
C) 3.8×10^{-24} N
D) 3.8×10^{-20} N
E) 1.6×10^{-21} N

Problem 7 (5 pts)
If an object moves at constant speed, you can irrefutably conclude that:

A) The object may be interacting with other objects in the universe, but the net interaction is zero
B) The object does not interact with anything in the universe
C) The net interaction with other objects in universe may be not zero, but it is constant in time
D) The object does not obey laws of physics
E) There is no gravity acting on that object

Problems 8-10

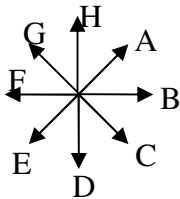An object of mass 2 kg moves at a constant speed 0.5 m/s along a path as shown.
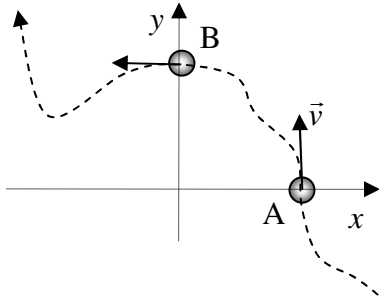
Problem 8 (5 pts)

What is the magnitude of the momentum change $|\Delta \vec{p}|$ when the object travels from point A to point B?

A) 0 kg·m/s
B) 1 kg·m/s
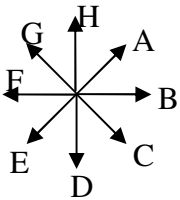C) 0.5 kg·m/s
D) 2 kg·m/s
E) 1.41 kg·m/s

Problem 9 (5 pts)

Which vector best represents the direction of $\Delta \vec{p}$ as the object travels from point A to B?

Problem 10 (5 pts)

What is the vector representing the direction of the average net force applied to the object while it traveled from A to B?

Problems 11-14

A 70 kg hockey layer sliding freely on his knees (no friction) on horizontal icy surface with velocity <-10,0,0> m/s. He then catches a 160g puck flying at speed <40,20,2> m/s (*z*-axis is vertical)

Problem 11 (5 pts)

What is the momentum of the player before he catches the puck?

A) <-700,0,0> kg·m/s
B) <210,1400,140> kg·m/s
C) <922,3211,0> kg·m/s
D) <432,4,0> kg·m/s
E) <4.32,0.04,0> kg·m/s

Problem 12 (5 pts)

What is the velocity of the player after he catches the puck? Note that the guy still slides along horizontal surface of the ice.

A) <9.9, 0.046, 0.0046> m/s
B) <-9.9, 0.046, 0> m/s
C) <-640, 3.2, 0.32> m/s
D) <-9.58, 0.003, 0.001> m/s
E) <-9.58, 0.003, 0> m/s

Problem 13 (5 pts)

What is the change in the momentum of the guy?

A) <60, 5, 1> kg·m/s
B) <600, 0, 0> kg·m/s
C) <0.06, 1, 0> kg·m/s
D) <7.7, 3.2,0> kg·m/s
E) <-50, 0, 0> kg·m/s

Problem 14 (5 pts)

What is the change in the momentum of the puck?

A) <60, 5, 1> kg·m/s
B) <600, 0, 0> kg·m/s
C) <0.06, 1, 0> kg·m/s
D) <-7.7, -3.2, -0.32> kg·m/s
E) <-50, 0, 0> kg·m/s

PHYS 172 - Spring 2010
Hand-Graded part of *Practice* Exam 1:

Name (Print):_____

Signature:_____

PUID:_____

When you use a fundamental principle you must explain clearly what physical system you are applying it to and which objects in the system's surroundings are interacting significantly with it.

Problem 1 (20 points)
You see your 10 kg bag sitting at rest on the floor at the airport baggage claim, and you rush over to grab it. You jerk the bag off the ground by pulling on it with a constant force of 130 N, at an angle of 70° above horizontal, for 0.1 seconds. The force of your pull is in the x-y plane (where the x-axis is parallel with the ground, and the y-axis points straight up in the air).

We want to know the velocity of the bag at the end of this 0.1 second period of tugging, and also the total distance through which the bag moved.

1.1. Define the system you're using in this problem.

1.2. List the external <u>objects</u> that interact significantly with the system. Make a carefully labeled diagram showing their interaction with the system. List an object that doesn't interact significantly with the system.

1.3. Use the momentum principle to find the velocity of the bag at the end of the 0.1 second period of time. Show all steps, include units, and circle the final answer. (*Note: You're not being asked for the speed of the box.*)

1.4. Through what total distance did the bag move during the 0.1 second period of time? Show all steps, include units, and circle the final answer.

Problem 2 (10 points)

As you are walking down a hallway in the Physics building you overhear two students discussing a Phys 172 problem in which two boxes are being moved across a loading dock. The smaller of the two boxes is on top of the larger one. As a worker pushes on the larger box, both boxes move together with increasing speed across the level, polished concrete floor.

One student says "The worker must be exerting a force on the top box, otherwise its motion would not be changing and it would be left behind as the bottom box moves." The other student responds "No, the worker isn't exerting any significant force on the top box because he isn't in contact with it. The motion of the top box does change though, so, it must be interacting significantly with some other object in its surroundings."

Starting from fundamental principles, how do you explain the changing motion of the top box in this situation? What objects in its surroundings is the top box interacting significantly with?

Equation list for exam I, PHYS 172, spring 2010

$$\vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t} \equiv \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i} \qquad \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} \equiv \frac{d\vec{r}}{dt} \qquad\qquad \vec{r}_f = \vec{r}_i + \vec{v}_{avg}\left(t_f - t_i\right)$$

$$r_f = r_i + \frac{v_i + v_f}{2}\left(t_f - t_i\right)$$

$$\vec{p} = \gamma m \vec{v} \qquad\qquad \gamma = \frac{1}{\sqrt{1 - \left(\dfrac{|\vec{v}|}{c}\right)^2}} \qquad\qquad \vec{v} = \frac{\vec{p}/m}{\sqrt{1 + \left(\dfrac{|\vec{p}|}{mc}\right)^2}}$$

$$\Delta \vec{p} = \vec{F}_{net}\Delta t \qquad \vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t \qquad \frac{d\vec{p}}{dt} = \vec{F}_{net} \qquad \Delta \vec{p}_{system} + \Delta \vec{p}_{surrounding} = \vec{0}$$

$$\frac{d\vec{p}}{dt} = \frac{d|\vec{p}|}{dt}\hat{p} + |\vec{p}|\frac{d\hat{p}}{dt} \qquad \left(\frac{d\vec{p}}{dt}\right)_{\perp} = p\frac{v}{R} = F_{\perp} \qquad \left(\frac{d\vec{p}}{dt}\right)_{\parallel} = \frac{dp}{dt} = F_{\parallel}$$

$$\left|\vec{F}_{spring}\right| = k_S\left|s\right| \qquad \frac{F_T}{A} = Y\frac{\Delta L}{L} \qquad k_s = \frac{A}{L}Y \qquad k_{int\,eratomic} = Yd$$

$$\vec{F}_{grav\ on\,2\,by\,1} = -G\frac{m_2 m_1}{\left|\vec{r}_{2-1}\right|^2}\hat{r}_{2-1} \qquad\qquad \vec{F}_{elec\ on\,2\,by\,1} = \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_1}{\left|\vec{r}_{2-1}\right|^2}\hat{r}_{2-1}$$

$$\Delta x \Delta p_x \geq h$$

$$\ddot{x}(t) = -\frac{k}{m}x(t) \qquad x = A\cos(\omega t) \quad \omega = \sqrt{\frac{k_s}{m}} \qquad T = \frac{2\pi}{\omega} \qquad f = \frac{1}{T}$$

Constants:

$$G = 6.7\times10^{-11}\ \frac{N\times m^2}{kg^2} \qquad \frac{1}{4\pi\varepsilon_0} = 9\times10^9\ \frac{N\times m^2}{C^2} \qquad h = 6.6\times10^{-34}\ \text{kg·m}^2/\text{s}$$

$$c = 3\times10^8\ \text{m/s} \qquad g = 9.8\ \text{N/kg} \qquad N_A = 6\times10^{23}\ \text{mol}^{-1}$$

Geometry:
$\pi = 3.14$
Circle: *circumference* $= 2\pi r$, *area* $= \pi r^2$
Sphere: *area* $= 4\pi r^2$, *volume* $= (4/3)\pi r^3$