PHYS 172 Practice Exam 1 - SOLUTIONS

1) **D**
2) **A**
3) **E**
4) **B**
5) **C**
6) **A**
7) **D**
8) **B**
9) **E**
10) **A**
11) **E** (direction of C) is correct but the correct magnitude is twice as large)

Mark your recitation time with an X

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

	Tu	W	Th	F
8.30				
9:30				
10:30				
11:30				
12:30				
1:30				
2:30				
3:30				
4:30				

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.

System = bag.
You can chose a different system – but you will have to stick to that system in the following questions.

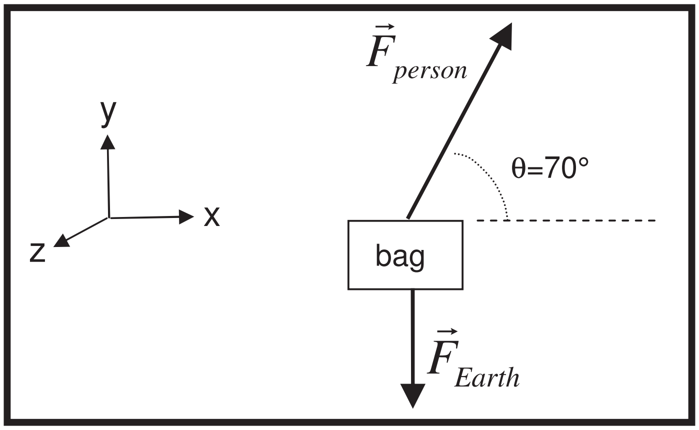
1.2. List the external objects that interact significantly with the system. Make a carefully labeled diagram showing their interaction with the system. List an object that doesn't interact significantly with the system.

Significant interaction: Earth, person

Insignificant:
Sun, Jupiter etc.

See diagram on the next page.

Note: the diagram depends on the choice of the system.
If you chose different system you should stick to it and use it in the diagram



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.)*

Momentum principle: $\Delta\vec{p} = \vec{F}_{net}\Delta t$, or $\vec{p}_f - \vec{p}_i = \vec{F}_{net}\Delta t$

Force:

$$\vec{F}_{net} = \vec{F}_{person} + \vec{F}_{Earth}$$

$$\vec{F}_{Earth} = \langle 0, -mg, 0\rangle = \langle 0, -98, 0\rangle N$$

$$\vec{F}_{person} = \left\langle F_{person}\cos\theta, F_{person}\sin\theta, 0\right\rangle = \langle 44.5, 122, 0\rangle N$$

$$\vec{F}_{net} = \vec{F}_{person} + \vec{F}_{Earth} = \left\langle F_{person}\cos\theta, F_{person}\sin\theta - mg, 0\right\rangle N$$

From the momentum principle find the momentum after 0.1s:

$$\vec{p}_f - \vec{p}_i = \vec{F}_{net}\Delta t$$

$$\vec{p}_f - 0 = \left\langle F_{person}\cos\theta, F_{person}\sin\theta - mg, 0\right\rangle \Delta t$$

$$\vec{p}_f = \langle 4.45, 2.42, 0\rangle kg\frac{m}{s}$$

Knowing momentum we can find the velocity:

$\vec{p} = \gamma m\vec{v} \approx m\vec{v}$ (use nonrelativistic approximation, $v << c$)

And the answer is:

$$\boxed{\vec{v}_f \approx \vec{p}_f / m = \langle 0.45, 0.24, 0\rangle m/s}$$

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.

Start from the position update (which is another form of definition of average velocity):

$$\Delta\vec{r} = \vec{v}_{ave}\Delta t$$

Under constant force, the average velocity is:

$$\vec{v}_{ave} = \tfrac{1}{2}\left(\vec{v}_f + \vec{v}_i\right) = \langle 0.22, 0.12, 0 \rangle\, m/s$$

Where initial velocity was 0. Therefore:

$$\Delta\vec{r} = \vec{v}_{ave}\Delta t = \langle 0.022, 0.012, 0 \rangle\, m$$

And the distance is:

$$\boxed{d = \sqrt{\left(\Delta\vec{r}\right)_x^{\,2} + \left(\Delta\vec{r}\right)_y^{\,2}} = 0.025\, m}$$

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?

The second student is correct. The worker is not interacting significantly with the top box because he is not in contact with it.

The top box is interacting significantly with the Earth and with the bottom box*. It is interacting gravitationally with the Earth and it is interacting with the bottom box by contact.

The vertical components of the forces exerted on the top box by the Earth and by the bottom box are equal in magnitude but opposite in sign so they cancel. Applying the momentum principle to the system consisting of the top box alone, we see that this explains why the vertical component of the momentum of the top box remains zero.

There is a horizontal component of static-friction force exerted on the top box by the bottom one. This is the net force on the system consisting of the top box alone and, so, applying the momentum principle to that system explains why the horizontal component of the momentum of the top box increases.

* Note: The top box is also in contact with the air (atmosphere). Because the net (buoyant) force exerted on the box by the air in negligible in this case, we did not mention it.