Physics 1408/1420 – General Physics 1

Week of September 5th, 2022

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Hello Fellow Physicists,

I hope you have had a wonderful start to this semester. I am Jorge Martinez-Ortiz, the Master Tutor for Physics this semester. I am a senior majoring in Physics, and Mathematics. To help you on your journey to learn about this wonderful branch of science and the understanding it gives us of the world around us, I will be preparing this resource every week to give you an additional tool to better prepare for your week. I will also be conducting Group Tutoring sessions every week, the information for which will be given below. If you are unable to attend group tutoring, the tutoring center also offers one-on-one tutoring session, so be sure to visit the tutoring center or visit https://baylor.edu/tutoring.

PHY 1408/1420 General Physics 1 Group Tutoring sessions will be held every Wednesday from 6:30-7:30 pm in the Sid Richardson building basement, Room 75. See you there!

In the past two weeks, your professors will have covered vectors and kinematics in one and two dimensions. This week, you will finish studying motion in two dimensions with projectile motion and explore Newtons laws of motion.

Important Notes
Important Conventions

Keywords: Projectile Motion, Forces, Newton's Laws

Important Topic 1: Projectile Motion

Projectile motion is the motion of an object thrown or projected into the air and is subjected only to the acceleration due to gravity. Projectile motion is motion in two dimensions. Thrown basketballs, batted baseballs, and kicked soccer balls are all examples of projectile motion.

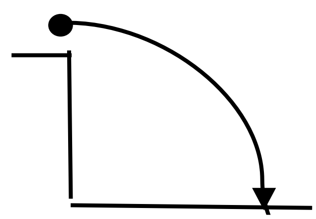
Projectile Motion involves the analysis of the motion using kinematics in two dimensions. An easy way to think of it is movement in the x-axis and y-axis. Each projectile abides by certain rules in both dimensions. In the y-axis, projectiles are subject to acceleration due to gravity. In the x-axis, projectiles are subject to no acceleration. In both axes, the time of motion is always the same. Remembering these three facts is very important for working with projectile motion.

First thing that we need to do when attempting a projectile motion problem is draw a rough diagram of the motion and list all known value for the five fundamental variables in both axes: initial velocity, final velocity, acceleration, displacement, and time. If either axis has known values for three of the five variables, the rest of the variable can be calculated using the kinematic equations. An easy method to follow is to split the space for both axes and then use the list of kinematic equations to solve the problem. We will see this in the solved example

Example 1:

A rock is thrown horizontally from a cliff of height 38 m and it lands 18 m from the base of the cliff. What is the initial velocity of the rock?

x-axis:	y-axis:
v_o= desired value	v_o= 0 m/s
v=	v=
a= 0 m/s^2	a= 9.8 m/s^2
d= 18 m	d= 38 m
t= 2.78 s	t= 2.78 s
d= $v_o t + ½(at^2)$	d= $v_o t + ½(at^2)$
18= $v_o(2.78)+1/2(0)(2.78^2)$	38= $(0)t+1/2(9.8)t^2$
18/2.78 = v_o	38/4.9 = t^2
v_o= 6.46 m/s	T^2= 6.46 m/s



v_o = initial velocity

v = final velocity

a = acceleration

d = displacement

t = time

Breaking down the motion in both axes is essential for understanding projectile motion.

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Important Topic 2: Forces

Force is generally defined as a push or pull that is experienced by a body. There are kinds of forces and the congregation of their effect forms the universe as we know it. There are contact forces, which require direct surface contact and there are non-contact forces like gravity, which can act from a distance. Newton was the first to define the relation between the forces and motion. He stated three laws of motion, which formed the foundation of the field of physics and its applications in every field of science.

Newton's Laws:

1. Every object remains at rest or stays in motion at a constant velocity until a net force act on it.
2. The acceleration of an object is directly proportional to the net force acting on it and is inversely proportional to the object's mass. The direction of the acceleration is in the direction of the net force acting on the object.
3. When an object exerts force on a second object, the second object exerts an equal force in the opposite direction on the first object.

The first law states that to accelerate an object, there must be a non-zero net force acting on the object. The second law states the main relation between force and acceleration, it is used to define the general equation for force

$$\text{Force} = \text{Mass} \times \text{Acceleration}$$

The third law explains why we do not fall through the earth. Together, these lay the foundation of the physics of forces.

There are many types of forces, the important ones to know are listed below as equations:

$$F_{\text{Kinetic Friction}} = \mu_k . F_{\text{normal}} \qquad F_{\text{Static Friction}} = \mu_s . F_{\text{normal}}$$

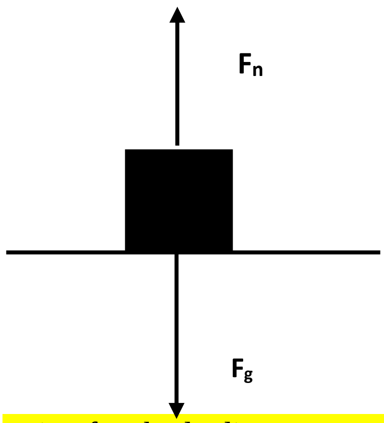
$$F_{\text{gravity}} = m.g \qquad F_{\text{spring}} = -kx$$

m – mass   a – acceleration   g = 9.8 m/s

k – spring constant μ_s – coefficient of static friction

μ_k – coefficient of kinetic friction x – spring displacement

Besides these formulas, the most important tool at your disposal are free body and dot diagrams. These are visualization methods that help with the analysis of the forces acting on a particular object. These make it easier to understand all the forces at play in a system. For example, let us consider the forces acting on a stationary box.



Free Body Diagram

Dot Diagram

Using free body diagrams or dot diagrams, breakdown all the forces in the system and find the net force. The example problem below will use dot diagrams and force equations to analyze the system.

Example 2:

Two boxes hang from either ends of a cable around a pulley. The two boxes are 0.4 kg and 0.6 kg, respectively. What is the tension force in the cable?

Box 1:

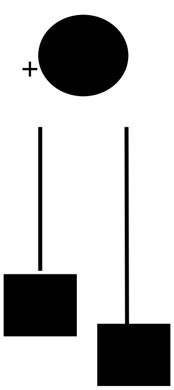
$\sum F = m_1 a$

$F_{Tension} - F_g = m_1 a$

$F_{Tension} - m_1 g = m_1 a$

$F_{Tension} - (0.4)(9.8) = (0.4)\,a$

$a = F_{Tension} - 3.92 / 0.4$



Box 2:

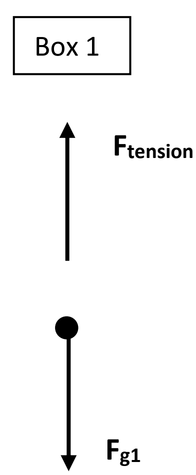
$\sum F = m_2 a$

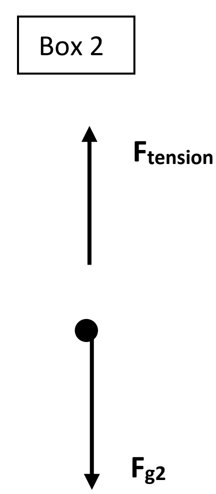
$F_{Tension} - F_g = m_2 a$

$F_{Tension} - m_2 g = m_1 a$

$F_{Tension} - (0.6)(9.8) = (0.6)\,a$

$a = F_{Tension} - 3.92 / -0.6$





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Both tension forces will be of the same magnitude as both boxes are attached to the same rope.

Once you have your dot diagrams, use the direction of the arrows to assign the positive or negative signs to each force variable.

Since a is the same for both boxes

$(F_{Tension} – 3.92 / 0.4) = (F_{Tension} – 3.92 / -0.6) \Rightarrow -0.6\ F_{Tension} + 2.352 = 0.4F_{Tension} – 2.352 \Rightarrow F_{Tension} = 4.704$ N

CHECK YOUR LEARNING

1. A rock is thrown horizontally form a 20 m tall cliff at 10 m/s. How far from the base of the cliff will the ball land?
2. What is harder to move 10 m from its initial position on the same surface, a box containing 1000 kg of feathers or a box containing 1000 kg of stainless steel?
3. A 10 kg box is place on an inclined plane with an elevation 30° from the ground. What is the coefficient of friction for the inclined plane if the box does not move after it is released?
4. A person steps on a scale in an elevator moving up at a uniform velocity. Will the weight displayed by the scale be higher than, lower than or equal to the weight displayed if the elevator was at rest?

THINGS YOU MAY STRUGGLE WITH

1. Seeing projectile motion problems as combination of different motion in two dimensions. Always remember to see the motion of the projectile as a movement in the x-axis and a movement in the y-axis.
2. Remember the rules for the motion in both axes. In the x-axis, there is NO acceleration. In the y-axis, there is an acceleration of magnitude $g= 9.8\ m/s^2$. Remember to regard the motion in y-axis in terms of directions relative to gravity to assign the correct sign to acceleration.
3. Always make sure to use dot diagrams to analyze the forces at play for a given system. They are a great tool for visualization and will come in handy in the future topics as well
4. Make sure to account for all the forces and analyze force problems in two dimensions as well. Always separate the x and y components of the force and operate on them separately in each dimension.
5. Divide the page into two sections for the two axes and work one the kinematics and forces for each dimension there. It will make it much easier to work through the problem.

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That is all I have for this week. Be sure to think about all that you learn and try to find the phenomena you study in everyday life. You can see projectile motion at play while playing basketball or see dot diagrams, all the forces at play, and the balance between them when you look at the pillars that support the BSB or your motion when you use the elevator to get to your room. Now, you see the world around in a wonderfully different way!

Please note that we will not have a group tutoring session on Monday the 5th due to Labor Day. Feel free to reach out to me if you have any questions and check out all the resources the Tutoring Center has to offer at: https://baylor.edu/tutoring

Answers: 1) 20.2 m, 2) Both require the same force, 3) 0.58, 4) Equal to weight at rest