Physics 1408/1420

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Hello Fellow Physicists

I am Aman Patel, the Master Tutor for Physics this semester. I have created this resource document to help you review some of the topics you have been introduced to this semester to better prepare for your Final in physics.

Keywords: Projectile Motion, Forces, Newton's Laws

Important Notes
Important Conventions

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.

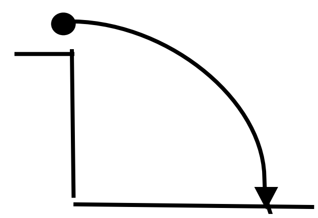
Projectile Motion involves the analysis of the motion using kinematics in two dimensions. An easy way to think of it is movement in the x-axis and y-axis. Each projectile abides by certain rules in both dimensions. In the y-axis, projectiles are subject to acceleration due to gravity. In the x-axis,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

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 has to 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

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

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

There are various forces and they can be calculated using the following equations:

$\mathbf{F_{net} = \sum Forces}$ $\mathbf{F = m.a}$ $\mathbf{F_{Kinetic\ Friction} = \mu_k . F_{normal}}$

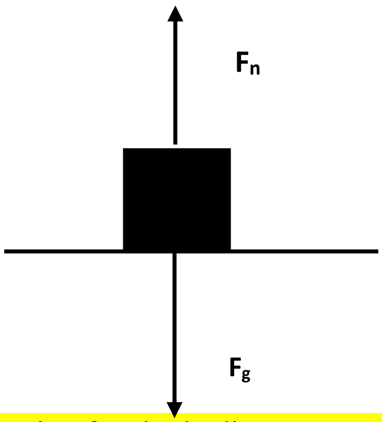
$\mathbf{F_{Static\ Friction} = \mu_s . F_{normal}}$ $\mathbf{F_{gravity} = m.g}$ $\mathbf{F_{spring} = -kx}$

m – mass a – acceleration g = 9.8 m/s k – spring constant

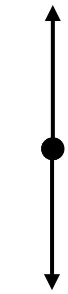
μ_s – coefficient of static friction μ_k – coefficient of kinetic friction

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:

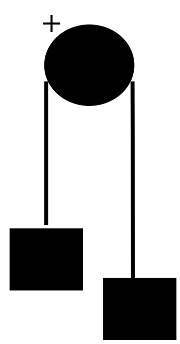
$\sum F = m_1 a$

$F_{Tension} - F_g = m_1 a$

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

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

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



Box 2:

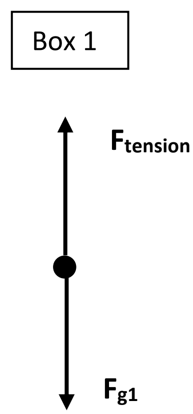
$\sum F = m_2 a$

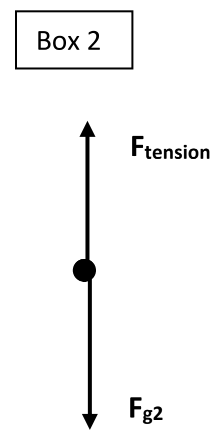
$F_{Tension} - F_g = m_2 a$

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

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

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





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

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

All images are from Physics: Principles with Applications (7th Edition) by Douglas C. Giancoli