



Journey to a Black Hole Labs: Teacher's Guide

This course is designed to enhance 10th grader's understanding of science, and provide them with a fun and engaging forum in which they can practice what they learn.

Lab 1: Escape Velocity Virtual Lab (Mission Map Module 5)

In this lab, students have to figure out how much energy is needed to escape Earth's gravitational field. They will perform the calculations for three different probes, each of a different weight. The heavier an object is, the greater the amount of energy that is needed in order to reach escape velocity. Students are also taught to use their resources wisely. If they use too little energy, the spacecraft will be stuck in Earth's orbit, and if they use too much energy, they won't have enough to launch the other vehicles. Thus, students must calculate the exact amount of energy that is needed to launch each probe.

Vocabulary	Science & Conceptual	Math
Escape Velocity	Gravity	Square Roots
Gravitational	Escape velocity	Division
Kinetic Energy	Energy conservation	Multiplication
Joule		Algebra

The correct answers are:

Galileo = 160814080000 or 1.6081408E+11 Joules

Cassini = 358256640000 or 3.5825664E+11 Joules

Voyager = 50176000000 or 5.0176E+10 Joules

Lab 2: Cloud Chamber Virtual Lab (Mission Map Module 20)

This lab educates students about cosmic rays and radiation by demonstrating the behavior of similar sub-atomic particles that can be observed on earth, namely radioactive isotopes. Students will use a virtual cloud chamber to observe the behavior and energy of Alpha, Beta, and Gamma Rays. They will then apply the skills they learned to complete the lab.

Vocabulary	Science & Conceptual	Math
Radiation	Electro-Magnetic Radiation	None
Radioactivity	Cosmic Rays and Radioactive Decay	
Cosmic rays		
Microwaves	Magnetic fields	
Wavelength		
Electromagnetic		
Supernova		
Alpha rays		
Beta rays		
Gamma rays		
Ionization		
Condensation		

This lab is divided into 4 activities.

Activity 1: Viewing the Traces of Alpha, Beta, and Gamma Rays

In this activity, students will see the typical cloud-chamber trace of Alpha, Beta, and Gamma rays.

Activity 2: Test the Density of Materials in the Cloud Chamber

Different particles of radiation have different levels of energy and as a consequence, can penetrate through different types of materials (paper, glass, lead) to varying degrees. In this exercise, the cloud chamber randomly emits all three types of radiation waves. Students will observe which rays go through each type of material,

The correct answers are:

Paper: Alpha rays do not penetrate

Glass: Alpha and Beta waves do not penetrate, but Gamma rays do.

Lead: Alpha, Beta, and Gamma rays do not penetrate

Activity 3: Test the Effect of Magnetism on Radiation Rays

In this activity, students will observe how Alpha, Beta, and Gamma rays react to an electromagnetic charge. The magnet in the cloud chamber represents a positive pole.

Alpha waves are repelled, are thus positively charged

Beta waves are pulled towards the magnet, and thus are negatively charged

Gamma waves are unaffected by magnet fields

Activity 4: Identify the Isotopes

In this activity students will apply the knowledge they have gained in this lab. They will place 3 different isotopes into the cloud chamber and will observe particle emission and magnetic reaction in order to identify the isotope.

The correct answers are:

Isotope 1 = Potassium 40, which emits 89% Beta rays, and 11% gamma rays

Isotope 2 = Cobalt 60, which emits 90% gamma rays and 10% beta rays

Isotope 3 = Radon 222, which emits 95% alpha rays, and 5% beta rays

Lab 3: Black Hole Hunting Virtual Lab (Mission Map Module 26)

This lab builds on the concepts introduced in the other two labs and relates them to the study of black hole; i.e. from Lab 1 the concept of escape velocity and gravity calculations, and from Lab 2, the electromagnetic spectrum and cosmic rays. In this lab students will learn about how astrophysicists study black holes using data from multiple space observatories, such as Swift, GLAST, and Chandra. Students will also learn how to calculate the diameter of a black hole based on the mass of the star from which it was created.

Vocabulary	Science & Conceptual	Math
Accretion disk	Astrophysics methodologies	Algebra
Afterglow	Electromagnetic spectrum	Multiplication
Atmosphere	Celestial Coordinate system	Division
Coordinates	Red-shift Spectroscopy	Exponents
Electromagnetic	GRBs (Gamma-ray Bursts)	
Gamma-ray burst	Escape Velocity	
Gravitational Collapse	Event Horizon	
Luminosity	Singularity	
Magnetic field	Gravity	
Phenomena		

Proportionate		
Red-shift		
Schwarzschild radius		
Singularity		
Spectrograph		
Ultraviolet		
Velocity		

Activity 1: Searching for Black Holes

In this activity, students have to analyze data pertaining to a cosmic event and determine whether or not the event signals the existence of a black hole. To be considered a likely black hole, the event must meet the following parameters:

- An event must have a gamma-ray signature between 10^{50} and 10^{51} .
- An event must have an x-ray afterglow with emissions above 10^{49} Ergs over a 1000 second period following a gamma-ray.

The correct answer at the end of the activity is:

Yes (the data are congruent with the existence of a black hole)

Activity 2: Determining the Radius of a Black Hole

In this activity, students will use the Schwarzschild radius calculation to determine the size of the black hole. They will do this by:

1. Multiplying the mass, which is $8E+30$ kilograms by the gravitational constant (G), which is $6.67E-11$.
2. Multiplying the product by the speed of light, which is $3E+5$ (300,000) kilometers per second.
3. And then dividing the first number by the second number.

The correct answer is:

11.85

Please note: because there are several different methods of rounding numbers, we consider and the lab will accept any answer between 11 and 11.99 as correct.

If you think this math is too advanced for your class, you could direct them to a Schwarzschild radius calculator, which can be found at

<http://fall.cerrocoso.edu/studenthelp/astronomy/Schwarzschild/schwarzschild.htm>