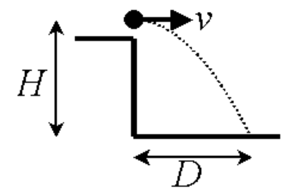
Due On: _______________ Name: __________________________

AP Physics 1: Review Packet 02

Problem 1: An object of mass m is projected horizontally from the top of a building. The object's initial velocity is v, its initial height is H, and it travels a horizontal distance D before striking the ground. Let t represent the time that the object is a projectile.



(a) Write two equations that relate the quantities v, H, D, t, and fundamental constants.

(b) Write a single equation that expresses D in terms of v, H, fundamental constants, and NOT time.

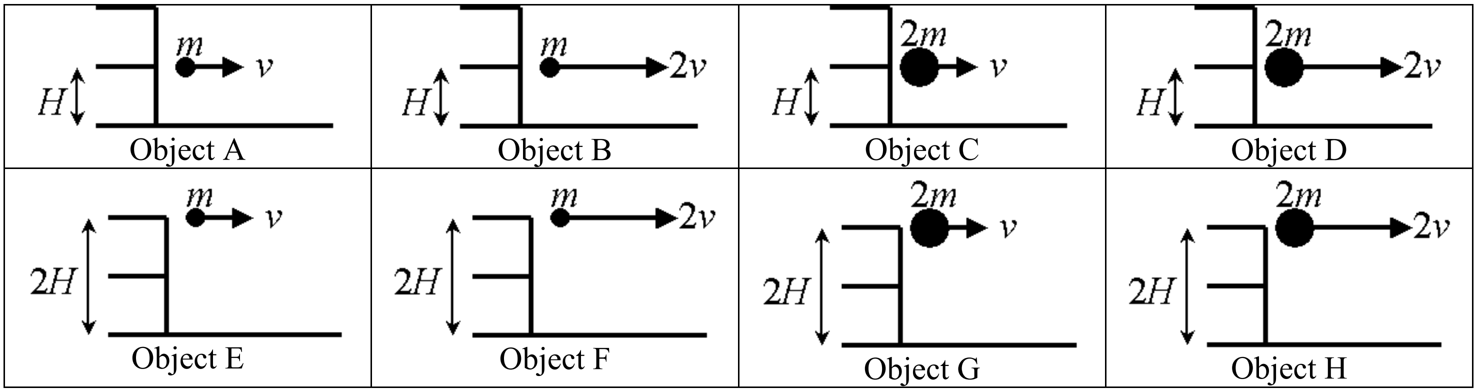
(c) Suppose the ball is launched a second time with greater initial velocity. What must the velocity be multiplied by in order to double the horizontal landing distance D? Explain your reasoning.

(d) Suppose the ball is launched a third time with the initial velocity v, but from a greater initial height. What must H be multiplied by in order to double the horizontal landing distance D? Explain your reasoning.

(e) In terms of the given quantities and fundamental constants, write an expression for the net force acting on the object while it is a projectile. Explain your reasoning.

(f) In terms of the given quantities and fundamental constants, write an expression for the object's kinetic energy just before striking the ground. Explain your reasoning.

Problem 2: Eight objects are launched horizontally from the top of a building. Some objects have mass m, the others have mass $2m$. Some objects are launched with initial speed v, others with initial speed $2v$. Some objects are launched from the middle of the building so that they have initial height H, the others are launched from the top of the building with initial height $2H$.



(a) Rank the objects based on the time that elapses while they are a projectile from longest to shortest amount of time. (If any objects have the same projectile time, put an equal sign between those letters.)

______ ______ ______ ______ ______ ______ ______ ______

Longest Projectile Time | Least Projectile Time

Briefly explain how you determined your ranking.

(b) Rank the objects based on the horizontal distance they travel before landing from farthest to shortest.

______ ______ ______ ______ ______ ______ ______ ______

Farthest Horizontal Distance | Shortest Horizontal Distance

Briefly explain how you determined your ranking.

(c) Rank the objects based on the acceleration (magnitude) each object has while it is a projectile.

______ ______ ______ ______ ______ ______ ______ ______

Highest Magnitude Acceleration | Lowest Magnitude Acceleration

Briefly explain how you determined your ranking.

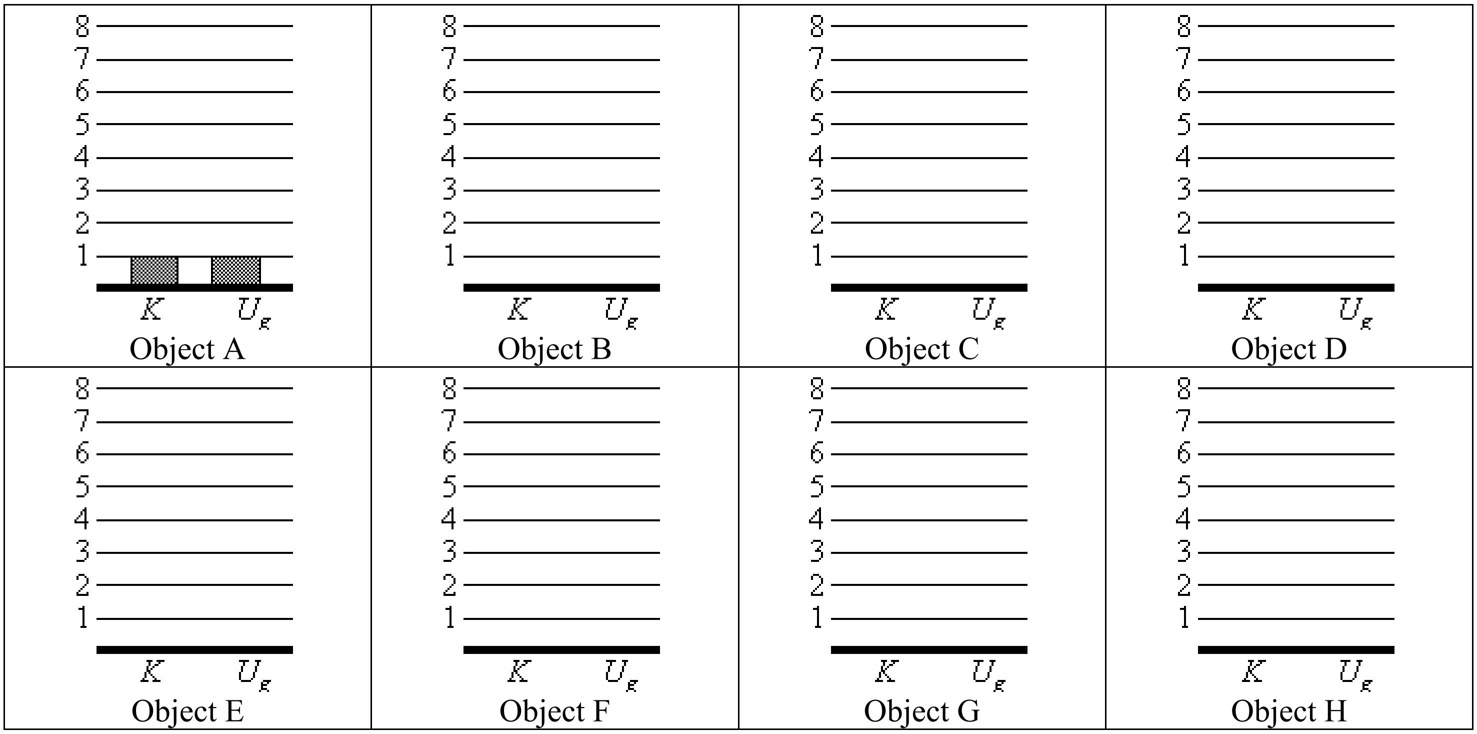
(d) Rank the objects based on the net force (magnitude) each object has while it is a projectile.

______ ______ ______ ______ ______ ______ ______ ______

Highest Magnitude Net Force | Lowest Magnitude Net Force

Briefly explain how you determined your ranking.

Suppose the value of v is such that $v = \sqrt{2gH}$. This would make it so that Object *A* starts with equal potential and kinetic energy. A bar graph for Object *A* is shown below for the instant just after it is launched.



(e) Fill in the remaining bar graphs for the other objects for the instants just after they are launched. Keep in mind that Object *A* has an initial velocity $1v$, initial height $1H$, and mass $1m$. Use the equations $K = ½mv^2$ and $U_g = mgh$ to correctly draw each bar at the correct height.

(f) Rank the objects based on their kinetic energy just before each strikes the ground. (Think about what final kinetic energy must be equal to. Then use your graphs to answer.)

________ ________ ________ ________ ________ ________ ________ ________

Greatest Final Kinetic Energy … Least Final Kinetic Energy

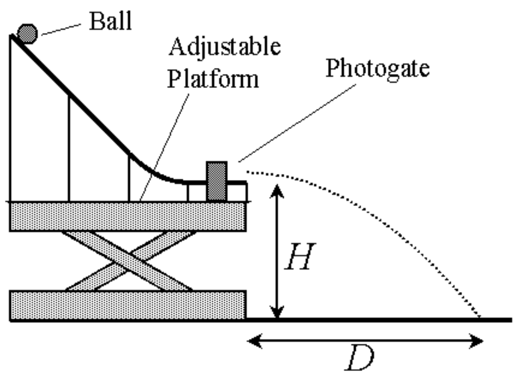
Briefly explain how you determined your ranking.

(g) Rank the objects based on their speed just before each strikes the ground. (Think about how final kinetic energy can be used to determine final speed.)

________ ________ ________ ________ ________ ________ ________ ________

Greatest Final Speed … Least Final Speed

Briefly explain how you determined your ranking.



Initial Speed: 1.26 m/s

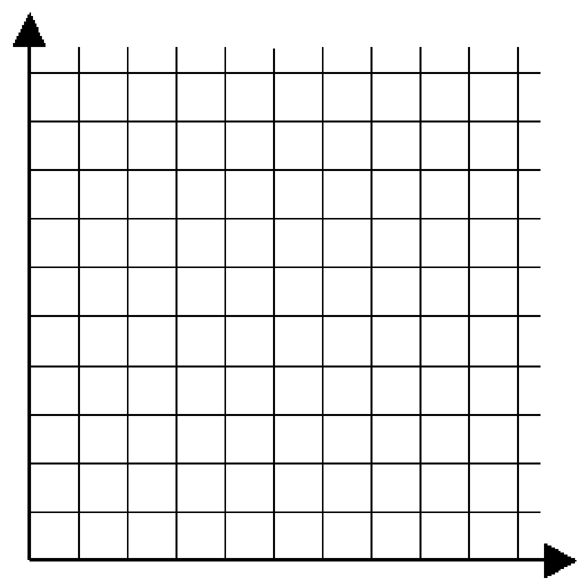
Height H [m]	Distance D [m]
0.50	1.02
1.00	1.41
1.50	1.72
2.00	1.98
2.50	2.22

x-variable	y-variable

Problem 3: On another planet, an experiment is performed in order to determine the acceleration of gravity at the surface. A platform that can be adjusted to different heights is set on the horizontal ground. A ramp is attached to the top of the platform; the lower end of the ramp has a flat section as shown.

First, multiple trials are done to show that, if the ball is released from rest at the top of the ramp, the speed of the ball at the bottom of the ramp is about 1.26 m/s. Then the height H of the bottom of the ramp is adjusted to the five values shown in the above data table. For each height H, the ball is released from rest and becomes a projectile at the bottom of the ramp. The horizontal distance D that the ball travels as a projectile is recorded.

(a) What quantities must be plotted in order to yield a straight-line relationship for the graph? Explain your reasoning. Fill those quantities in the right table above.



(b) Plot the two quantities on the grid to the right. Label each axis with a symbol, units, and scale. Draw a best-fit line.

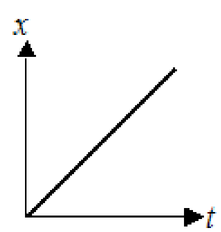
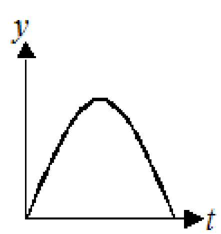
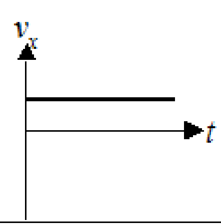
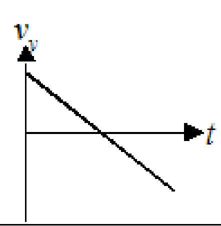
(c) Use the slope of the best-fit line to calculate the acceleration of gravity on this planet. Make sure you clearly show what the value of the slope is and how it was used.

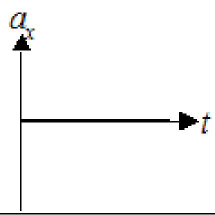
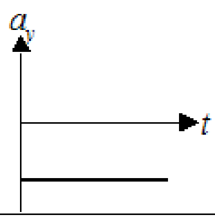
Projectile Motion Review

IMPORTANT EQUATIONS

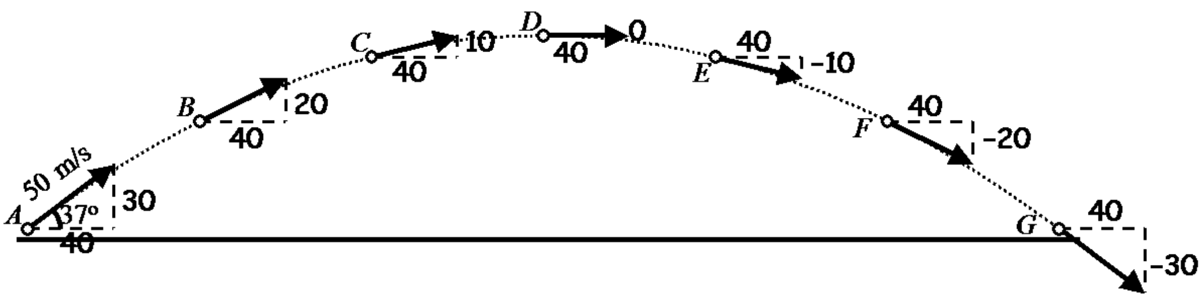
Name	Equation	Given?	Notes
Horizontal Component of Initial Velocity	$v_{0x} = v_0 \cos\theta$	No	The *x*-component of anything is magnitude times cosine of the angle.
Vertical Component of Initial Velocity	$v_{0x} = v_0 \sin\theta$	No	The *y*-component of anything is magnitude times sine of the angle.
Horizontal Distance as a Function of Time	$x = v_{0x}t + x_0$	No	Constant velocity in the horizontal direction.
Vertical Height as a Function of Time	$y = -\frac{1}{2}gt^2 + v_{0y}t + y_0$	No	Constant acceleration in the vertical direction.
The *x*-component of velocity is constant.	$v_x = v_{0x}$	No	Constant velocity in the horizontal direction.
Y-component of velocity as a function of time.	$v_y = -gt + v_{0y}$	No	Constant acceleration in the vertical direction.
Maximum Horizontal Range	$R = \frac{{v_0}^2}{g} \sin 2\theta$	No	Only true on flat surfaces (when $y = y_0$). Note that maximum range occurs when angle is 45.
Maximum Height	$H = \frac{{v_0}^2}{2g} \sin^2\theta + y_0$	No	Note that maximum height occurs when angle is 90.

IMPORTANT GRAPHS

Name	Graph (Shape)	Notes
Horizontal Position vs. Time		Remember that, in the horizontal direction, the motion is constant velocity. This makes the graph of *x* vs. *t* a line with slope v_{0x}.
Vertical Position (Height) vs. Time		In the vertical direction, the motion is constant acceleration, making the graph a parabola. The acceleration is downward, so the parabola opens downward.
Horizontal Velocity vs. Time		Remember that, in the horizontal direction, the motion is constant velocity. This makes the graph of v_x vs. *t* a flat line with value v_{0x}.
Vertical Velocity vs. Time		In the vertical direction, the motion is constant acceleration, making the graph a line. The acceleration is –9.8 m/s^2, so the line has a constant negative slope of –9.8.

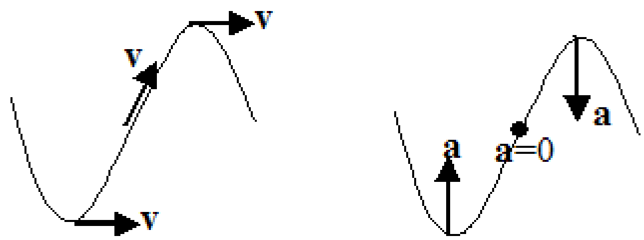
Horizontal Acceleration vs. Time		The motion in the horizontal direction is constant velocity, which automatically makes acceleration zero.
Vertical Acceleration vs. Time		The motion in the vertical direction is constant acceleration. The acceleration is $-9.8\ m/s^2$, so the flat line has a constant negative value of -9.8.

(Let $g = 10\ m/s^2$) Gravity subtracts 10 m/s from the vertical velocity every second. Horizontal velocity never changes:



IMPORTANT CONCEPTS

- An object in free fall has only the force of gravity acting on it.
- If an object is in free fall, it has an acceleration of $9.8\ m/s^2$ downward, even if it is at the peak of its arc. <u>They always try to trick you on this concept!</u>
- The speed of an object in projectile motion is highest at the bottom of its path. The speed is slowest at the peak (though it may not be zero!). This is because the object's potential energy is the most at its peak, so its kinetic energy is least.
- The direction of velocity at a certain point is always <u>tangent to the path</u> that an object travels.
- The direction of acceleration at a certain point is always <u>toward the center of the circle</u> made by the curvature of the path.



If a projectile is launched horizontally, then you can use the shorter projectile motion equations $y_0 = \frac{1}{2}gt^2$ and $x = vt$. These are good to memorize for the multiple choice.