Physics Unit 5 Study Guide
Projectiles

Essential Questions:

1) **How is a projectile's motion affected by gravity?**
2) **How do the components of a projectile's motion effect one another?**

Words to define!

- Projectile
- Hang Time
- Max Height
- Range

Equations to use!

$\mathbf{v = \frac{\Delta x}{t}} \rightarrow \mathbf{x_f = vt + x_o}$ ***Constant Motion***

$\mathbf{a = \frac{\Delta v}{t}} \rightarrow \mathbf{v_f = at + v_o}$ ***Accelerated Motion***

$\mathbf{\Delta x = \frac{1}{2}at^2 + v_ot}$

$\mathbf{v_f^2 = v_o^2 + 2a\Delta x}$

$\mathbf{g = 9.8\, {}^{m}/_{s^2}}$

Skills to have!

S1 – Know how to find the hang time, max height, range, and each component of the final velocity for a projectile.

Concepts to know!

C1 – There are many things that we know for projectiles:

a. Always, $\mathbf{a_x = 0\, {}^{m}/_{s^2}}$ and $\mathbf{a_y = -9.8\, {}^{m}/_{s^2}}$
b. If a projectile starts with a velocity at an angle, the horizontal and vertical components (*sin* and *cos*) of that velocity have to be determined before beginning.
c. When a projectile starts and ends at the same height, $\Delta y = 0\ m$.
d. At the top of a projectile's path, $v_{fy} = 0\, {}^{m}/_{s}$.
e. Hang time needs to be determined before range is determined.
f. Hang time is affected only by the vertical and the equation for hang time will be $\mathbf{\Delta y = \frac{1}{2}a_yt^2 + v_{oy}t}$
g. Max height is only vertical and will use the equation $\mathbf{v_{fy}^2 = v_{oy}^2 + 2a_y\Delta y_{max}}$
h. Range is only horizontal and will use the equation $\mathbf{\Delta x = \frac{1}{2}a_xt^2 + v_{ox}t}$ where $\mathbf{a_x = 0\, {}^{m}/_{s^2}}$.

Example Problems!

1. A busy waitress slides a plate of apple pie along a counter to a hungry customer sitting near the end of the counter. The customer is not paying attention, and the plate slides off the counter horizontally at 0.84 $^{m}/_{s}$. The counter is 1.38 m high.
   a. How long does it take the plate to fall to the floor? ($\boldsymbol{t = 0.53\ sec}$)
   b. How far from the base of the counter does the plate hit the floor? ($\boldsymbol{\Delta x = 0.45\ m}$)
   c. What are the horizontal and vertical components of the plate's velocity just before it hits the floor? ($\boldsymbol{v_{fx} = 0.84\ ^{m}/_{s},\ v_{yf} = -5.2\ ^{m}/_{s}}$)

2. A tennis ball is thrown with a speed of 21.0 $^{m}/_{s}$ at an angle of 40.0° above the horizontal. It is then caught by another person at the same height from which it was thrown.
   a. How long is the tennis ball in the air? ($\boldsymbol{t = 2.75\ sec}$)
   b. What is the highest that the ball goes above where it was thrown? ($\boldsymbol{\Delta y_{max} = 9.30\ m}$)
   c. How far did the ball move between the people throwing the tennis ball? ($\boldsymbol{\Delta x = 44.3\ m}$)
   d. What was the vertical component of the velocity the moment before the tennis ball was caught? ($\boldsymbol{v_{fy} = -13.5\ ^{m}/_{s}}$)

3. A marble rolls off the edge of a table that is 0.734 m high. The marble is moving at a speed of 0.122 $^{m}/_{s}$ at the moment that it leaves the edge of the table. How far from the table does the marble land? ($\boldsymbol{Hang\ Time = 0.387\ sec,\ \ Range = 0.0472\ m}$)

PHYSICS STUDY GUIDE
CHAPTER 6: PROJECTILE MOTION

TOPICS:

- Projectile motion:
  - Case I – Free fall
  - Case II – Horizontal launch
  - Case III – Vertical launch
  - Case IV – Angled launch

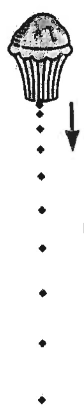
PROJECTILE MOTION

- Motion of an object under the influence of Earth only.

CASE I – FREE FALL

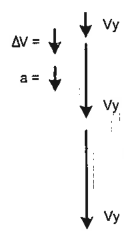
- Object falls from rest (v_{yi} = 0 m/s)
- Vertical motion: Motion with constant acceleration $a_y = -9.8\ m/s^2$

SKETCH

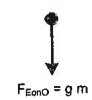


The dots shown represent the position of a muffin in free fall at one second intervals

MOTION DIAGRAM



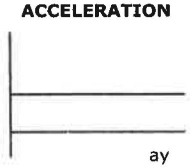
FORCE DIAGRAM



Object is under the influence of Earth only.

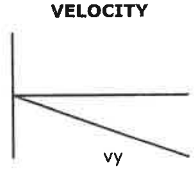
Earth always exerts the same force $F_{EonM} = g \cdot m$

ACCELERATION



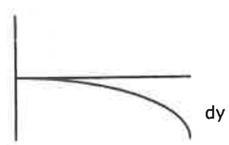
The vertical acceleration of the objects is constant $-9.8\ m/s^2$

VELOCITY



The initial vertical velocity of the object is 0 m/s and speeds up in the negative direction

POSITION

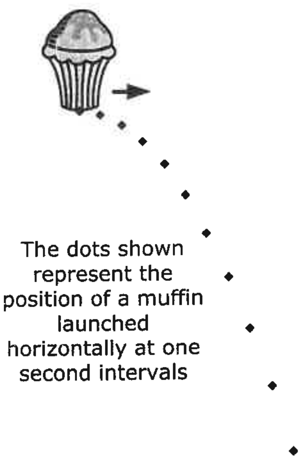


The initial vertical position of the object is 0 m. The position changes with the square of the time (Δt^2)

CASE II – HORIZONTAL LAUNCH

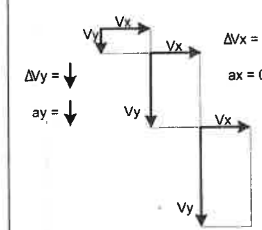
- Object falls from rest (v_{yi} = 0 m/s) with a horizontal velocity.
- Horizontal motion: Motion with constant velocity (v_x = constant , $a_x = 0\ m/s^2$)
- Vertical motion: Motion with constant acceleration ($a_y = -9.8\ m/s^2$)

SKETCH



The dots shown represent the position of a muffin launched horizontally at one second intervals

MOTION DIAGRAM



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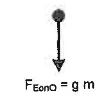
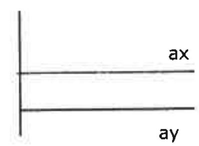


Object is under the influence of Earth only.

Earth always exerts the same force $F_{EonM} = g \cdot m$

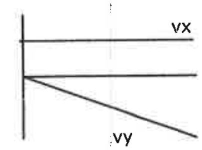
ACCELERATION



The vertical acceleration of the objects is constant $-9.8\ m/s^2$

The horizontal acceleration of the objects is constant $0\ m/s^2$ (Earth only exerts a downward force)

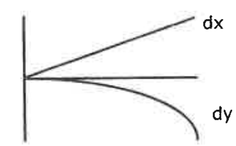
VELOCITY



The initial vertical velocity of the object is 0 m/s and speeds up in the negative direction

The horizontal velocity of the object **is constant** (stays the same)

POSITION



The initial vertical position of the object is 0 m. The position changes with the square of the time (Δt^2)
The initial horizontal position of the object is 0 m. The position **changes** with the time and the object moves forward,

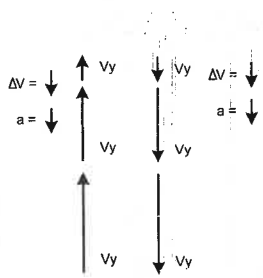
CASE III – VERTICAL LAUNCH

- Vertical motion: Motion with constant acceleration ($a_y = -9.8\ m/s^2$)
- The object is launched with an initial POSITIVE velocity (so the object can go up and reach the maximum height)
- The object has negative acceleration and slows down on its way up.
- The object at the maximum height reaches a velocity $vy_{TOP} = 0$ m/s.
- The object has negative acceleration and speeds up on its way down.
- The time going up is the same time coming down (The object has the same vertical acceleration going up and going down).

SKETCH

The dots shown represent the position of a muffin launched vertically at one second intervals

MOTION DIAGRAM



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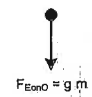
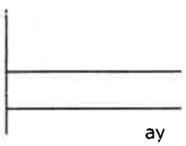


Object is under the influence of Earth only.

Earth always exerts the same force $F_{EonM} = g \cdot m$

ACCELERATION



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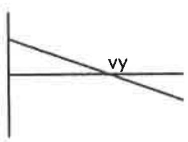
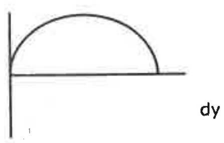
VELOCITY



The initial vertical velocity of the object is POSITIVE. The object slows down until the its velocity is zero ($vy_{TOP} = 0$ m/s), then the objects starts to speed up in the negative direction.

POSITION

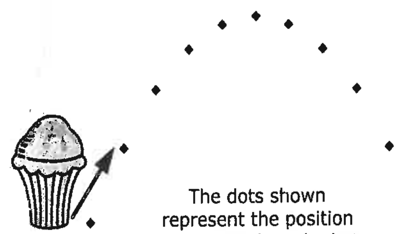


The initial vertical position of the object is 0 m. The position changes with the square of the time (Δt^2). The object goes all the way to the top (dy_{TOP}) and comes back down.

CASE IV – ANGLED LAUNCH

- Vertical motion: Motion with constant acceleration ($a_y = -9.8\ m/s^2$)
- Horizontal motion: Motion with constant velocity (v_x = constant , $a_x = 0\ m/s^2$)
- The object is launched with an initial POSITIVE velocity (so the object can go up and reach the maximum height)
- The object has negative vertical acceleration and slows down on its way up.
- The object at the maximum vertical height reaches a velocity $vy_{TOP} = 0$ m/s.
- The object has negative vertical acceleration and speeds up on its way down.
- The time going up is the same time coming down (The object has the same vertical acceleration going up and going down).

SKETCH



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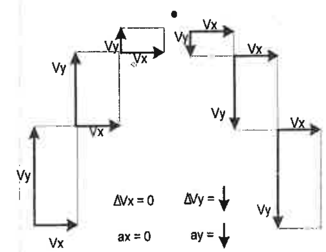

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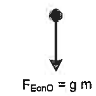

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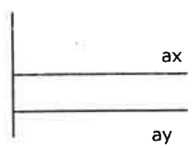

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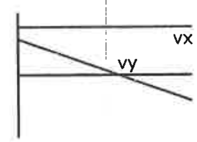
VELOCITY



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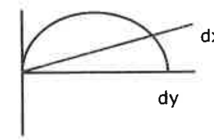
POSITION



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The initial horizontal position of the object is 0 m. The position **changes** with the time and the object moves forward,