KEY

Notes 5.1 – Circular Speed & Velocity

Review of Terms:

1. Scalar: quantity with magnitude only
2. Vector: quantity with magnitude & direction
3. Speed: scalar quantity, $s = \frac{\text{distance}}{\text{time}}$
4. Velocity: vector quantity, $v = \frac{\text{displacement}}{\text{time}}$
5. Acceleration: change in velocity
6. Force: push or pull that causes acceleration

Review Questions:

1. If you change your speed, do you change your velocity?
   Yes because velocity is just your speed + direction
2. If you change your velocity, do you change your speed?
   Not necessarily – you can change direction & keep the same speed
3. Can you be accelerating while maintaining a constant speed?
   Yes – acc. is a change in velocity, which could be a change in direction.
4. Can you be accelerating while maintaining a constant velocity?
   No.

Notes:

I. Speed & Velocity

A. Uniform circular motion – motion in which the <u>speed</u> & <u>radius</u> don't change, but the <u>direction</u> changes at a constant rate.

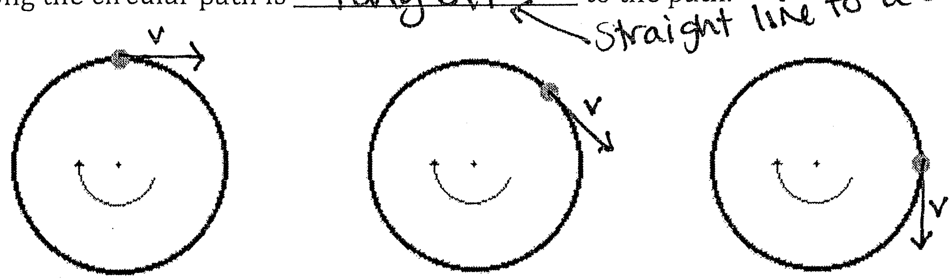
B. Calculating circular motion:

$$\text{speed} = \frac{\text{circumference}}{\text{time}} \rightarrow \frac{2\pi r}{T}$$

r ← radius
T ← period (time around once)

Increase radius → increase speed
Increase period → ~~increase~~ decrease speed.

C. Direction – <u>Changes</u> at a constant rate. The direction of velocity at any point along the circular path is <u>tangent</u> to the path.
← straight line to a curve



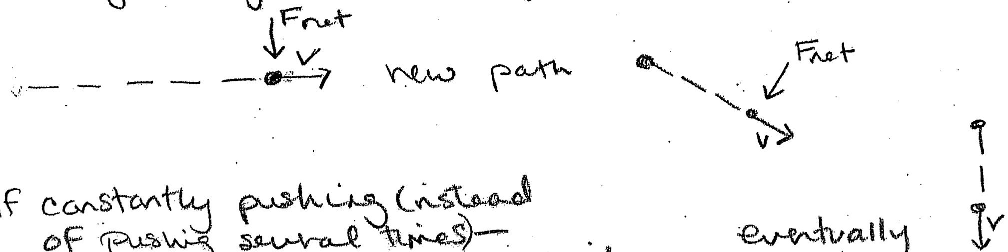
Notes 5.2 – Acceleration & Force in Circular Motion

Name: ______________________ Date: ______________ Hour: ________

I. Acceleration & Force

A. Situation – A person is walking in a straight line at a constant speed. Someone comes up and pushes him at a 90-degree angle to his path. What would be his new path of motion?

at a slight angle to his original path



* If constantly pushing (instead of pushing several times)— path would be a smooth circle
* Circular path cause by constant Force in!

Why is this his new path? (Why is he not moving at a path 90-degrees to the original?)

Inertia = resistance to change in motion. Object/person wants to continue his original path (tangent to circle).
Original path + force's path = new path (combo of 2 directions).

B. Acceleration

1. Calculating acceleration:

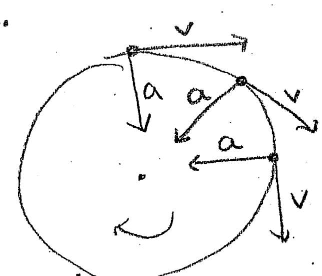
$$a = \frac{v^2}{r}$$

change in circular motion → so must use circular speed/velocity.

* increase speed → increase acc.
* increase radius → decrease acc.

2. Direction of ~~force~~ acceleration:

Think—not causing speed up/slow down... causing change in direction!



must be ⊥ or it will cause you to speed up/slow down as well.

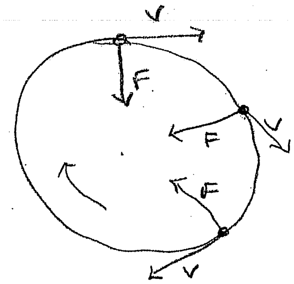
C. Centripetal Force

1. Calculating force:

$$F_{net} = ma \longrightarrow F_{net} = \frac{mv^2}{r}$$

* increase m → ↑ Force
* increase v → ↑ Force
* increase R → decrease Force

2. Direction of force:



3. Types of forces that can cause circular (centripetal) motion:

- Shoe on a string → tension in string
- car on the road → friction between tires
- Cart on roller coaster → normal force of track pushing cart
- satellite in space → gravity between Earth & satellite

D. The Forbidden F-Word! = Centrifugal

* means "outward" ← no outward force exists!
* Inertia causes you to feel like you are being pulled outward because your tendency is to keep going in the orginal direction

— You are not being pulled outward!
— You are being held inward!

Notes 5.3 – Gravity

Name: KEY Date: ________ Hour: ______

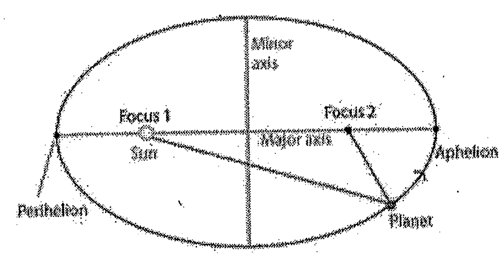
Learning Goals:
- Distinguish between the terms revolution & rotation
- Explain how gravity was discovered
- Predict how changes in distances effect gravitational force

III. Gravity
  A. Common Use of Term:
  - why things fall
  - reasoning behind "what goes up must come down"
  B. Force of Gravity:
  - slows us as we rise
  - speed us as we fall
  C. Acceleration due to Gravity: $g = 9.8 m/s^2$ down – for all objects on Earth in free fall (only gravity)

  D. History Lesson:
    1. Terms:
      a. Revolve – go around something (orbit)

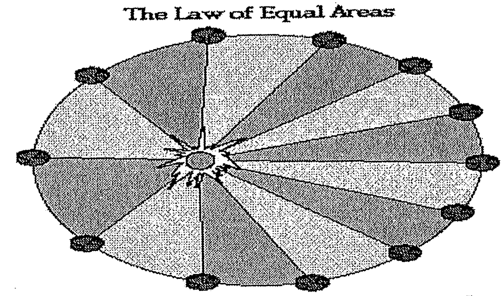
      b. Rotate – spin on axis

    2. Kepler's Laws of Planetary Motion: Studied astronomical data of mentor to come up with 3 laws of how planets move:
      a. Law of Ellipses:
      Planets revolve in elliptical patterns around the sun



An elliptical orbit of a planet (greatly exaggerated)

The Law of Equal Areas


An imaginary line drawn from the sun to any planet sweeps out equal areas in equal amounts of time.

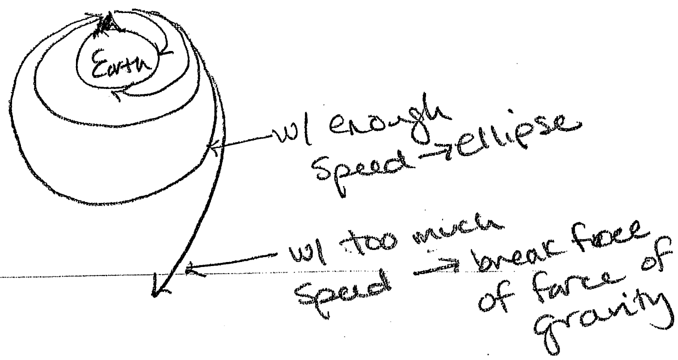
      b. Law of Equal Areas:
      Every second planets "sweep out" the same amount of area.

c. Law of Harmonies: $\frac{T^2}{R^3}$ → equal for all planets about the sun.

3. Newton & The Apple:

Event w/ apple not recorded?

He proposed that what pulls an apple/object down is the same force that attracts 2 objects to eachother (~~keep~~ orbital motion)



This works for EVERYTHING
↳ even light
* why black holes are black.
light can't go fast enough.

E. Inverse Square Law: Force of gravity b/tw 2 objects are equal & opposite (3rd law) But its dilluted by distance $F_g \propto \frac{1}{d^2}$

$\frac{g_{moon}}{g_{apple}} = \frac{.00272}{9.8} = \frac{1}{3600}$

moon is 60x farther away

$\frac{1}{(60)^2} = \frac{1}{3600}$

Example Problems:

1. Suppose that two objects attract each other with a gravitational force of 16 units. If the distance between the two objects is doubled, what is the new force of attraction between the two objects?

$\frac{16}{(2)^2} = \frac{16}{4} = 4$ units

2. Suppose that two objects attract each other with a gravitational force of 16 units. If the distance between the two objects is tripled, then what is the new force of attraction between the two objects?

$\frac{16}{(3)^2} = \frac{16}{9} = 1.78$ units

3. Suppose that two objects attract each other with a gravitational force of 16 units. If the distance between the two objects is reduced in half, then what is the new force of attraction between the two objects?

$\frac{16}{(\frac{1}{2})^2} = \frac{16}{\frac{1}{4} \text{ or } .25} = 64$ units

Notes 5.4 – Law of Universal Gravitation

Name: ______________________ Date: __________ Hour: ______

IV. Newton's Law of Universal Gravitation

A. Explanation

* Newton discovered dependence of gravity on distance
* But he did said F=ma ← so mass must be included

B. Equation

$$F_g = \frac{G m_1 m_2}{d^2} \qquad G = 6.673 \times 10^{-11} \frac{Nm^2}{Kg^2}$$

C. Practice Problems

1. Determine the force of gravitational attraction between the earth (m = 5.98 x 1024 kg) and a 70-kg physics student if the student is standing at sea level, a distance of 6.38 x 106 m from earth's center.

$$F = \frac{(6.673 \times 10^{-11})(5.98 \times 10^{24})(70)}{(6.38 \times 10^{6})^2} = 686 N$$

2. Determine the force of gravitational attraction between the earth (m = 5.98 x 1024 kg) and a 70-kg physics student if the student is in an airplane at 40000 feet above earth's surface. This would place the student a distance of 6.39 x 106 m from earth's center.

$$F = \frac{(6.673 \times 10^{-11})(70)(5.98 \times 10^{24})}{(6.39 \times 10^{6})^2} = 684 N$$

V. The Value of "g"

A. Equation

If $F_g = mg$ and $F_g = \frac{G m_1 m_2}{d^2}$ → $m_{apple} g = \frac{G m_{apple} m_2}{d^2}$

$g = \frac{G m}{d^2}$ ← the object that is pulling

B. Practice Problems – Fill in the chart.

Planet	Radius (m)	Mass (kg)	g (m/s²)
Earth	6.38×10^{6} m	5.98×10^{24}	
Mercury	2.43×10^{6}	3.2×10^{23}	
Venus	6.073×10^{6}	4.88×10^{24}	
Apple	~~.25~~ .05	.25	

$$g_E = \frac{6.673 \times 10^{-11} (5.98 \times 10^{24})}{(6.38 \times 10^{6})^2} = 9.8 \text{ m/s}^2$$

$$g_m = \frac{6.673 \times 10^{-11} (3.2 \times 10^{23})}{(2.43 \times 10^{6})^2} = 3.61 \text{ m/s}^2$$

$$g_v = \frac{6.673 \times 10^{-11} (4.88 \times 10^{24})}{(6.073 \times 10^{6})^2} = 8.83$$