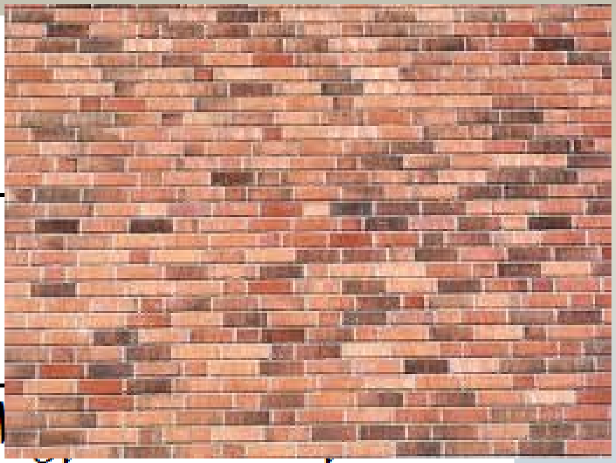
Physics 2211: *Matter and Interactions*

Class III (interactions and momentum)

Todays objective:

Using the momentum principle with **constant** Forces



but the

$$\frac{d\,\vec{p}}{d\,t} = \vec{F}_{net}$$ that kills you!

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Howey Room C203

Office Hours: Weds 7-9 am and/or by appointment

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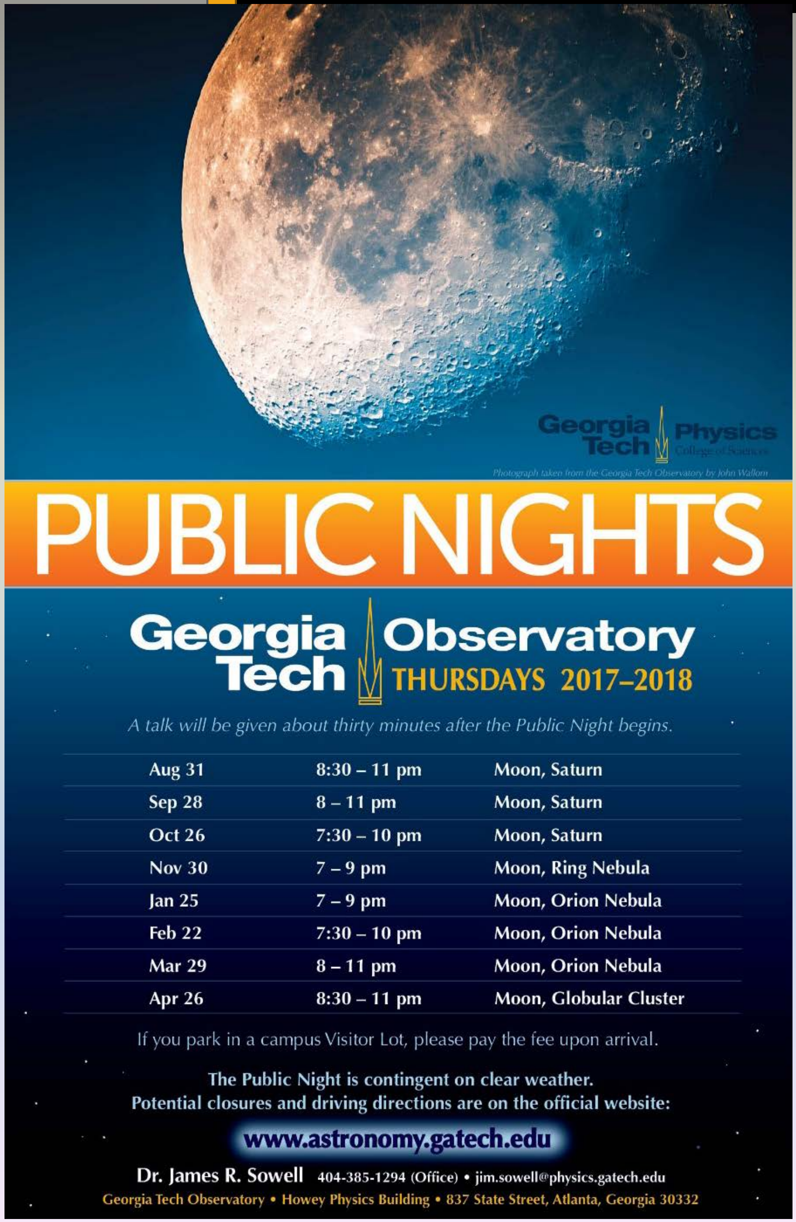

Jan 25	7 – 9 pm	Moon, Orion Nebula
Feb 22	7:30 – 10 pm	Moon, Orion Nebula
Mar 29	8 – 11 pm	Moon, Orion Nebula
Apr 26	8:30 – 11 pm	Moon, Globular Cluster

If you park in a campus Visitor Lot, please pay the fee upon arrival.

The Public Night is contingent on clear weather.
Potential closures and driving directions are on the official website:

www.astronomy.gatech.edu

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eorgia Tech Observatory • Howey Physics Building • 837 State Street, Atlanta, Georgia 30332

The Kinematic Equations

$$v = v_0 + at$$

$$\Delta x = v_0 t + \tfrac{1}{2}at^2$$

$$v^2 = v_0^2 + 2a\Delta x$$

$$\Delta x = \bar{v}t = \tfrac{1}{2}(v + v_0)t$$

$$\Delta x = vt - \tfrac{1}{2}at^2$$

You all know these equations, but where did they came from?

Yes! From $\dfrac{d\vec{p}}{dt} = \vec{F}_{net}$ when $\vec{F}_{Net}$ = Constant and v << C

Physics 2211: *Matter and Interactions*

- **The momentum principle (a special case)**
  - What if the net force is always constant?
  - What if the speed is much less than **c**? And mass is constant
  - We can use Calculus to determine an exact solution to the momentum principle (Newtons second law)
- **The kinematic equations**

(1) $$\frac{d\vec{p}}{dt}=\vec{F}_{\text{net}}$$

(2) $$\vec{p}=\vec{F}_{\text{net}}*t+\vec{C}_1$$

(3) $$m\frac{d\vec{r}}{dt}=\vec{F}_{\text{net}}*t+\vec{C}_1$$

(4) $$m\vec{r}=\frac{1}{2}\vec{F}_{\text{net}}*t^2+\vec{C}_1*t+\vec{C}_2$$

The Kinematic Equations

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What about for Y and Z??

Yes! From $\dfrac{d\vec{p}}{dt} = \vec{F}_{net}$ when $\vec{F}_{Net}$ = Constant and v << C

Example 1: Only motion on the x axes

Example 2: Only motion on the y axes

Example 3:   3 dimensional motion

All considering **constant** forces

Example 1: A fan cart with m= 0.5Kg has the fan on and produces a net Force of <0.2,0,0>N, you give the cart a shove, and release the cart at position <0.5,0,0>m with initial velocity <0.3,0,0> m/s.

- What is the momentum of the cart 0.6 seconds later?
- What is its velocity at that time? **V_{fx} = 0.54 m/s**
- Predict the position of the cart at that time.

$$\Delta\vec{p} = \vec{F}_{net}\Delta t = \text{Impulse}$$

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t$$

P_f= <0.3,0,0>*.5 kgm/s + <0.2,0,0>*0.6 kgm/s = <0.27,0,0> kgm/s

V = <0.27,0,0>kg m/0.5s kg = <0.54,0,0> m/s

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X_f Can be obtained in 4 different ways:

$X_f = X_o + V_{ox}\, t + F_y t^2/2m = 0.5 + 0.3*0.6+0.2*0.36/(2*.5) = 0.752\text{m}$

$X_f = X_o + V_{avg}\, t$ where $V_{avg} = (V_{ox}+V_{fx})/2$

$X_f = X_o + V_{ox}\, t + at^2/2$ where $a = \Delta V/\Delta t$

$X_f = X_o + (V_{fx}^2 - V_o^2)/2a$

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$X_f = X_o + V_{avg}\, t = 0.5+(0.3+0.54)/2)*0.6 = 0.752\text{m}$

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$X_f = X_o + V_{ox}\,t + at^2/2$ =0.5+0.3*0.6+(.54-.3)*$(0.6)^2$/(2*.6) = 0.752m

$X_f = X_o + (V_{fx}{}^2 - V_o{}^2)/2a$ =0.5+(0.54*0.54-0.3*0.3)/(2*0.4) = 0.752m

Physics 2211: *Matter and Interactions*

- **SRS:** *Two metal balls are the same size but one weighs twice as much as the other. The balls are dropped from The Leaning Tower of Pisa at the same instant of time. The force on a ball is constant and given by* **F = <0, -mg, 0>**. *The time it takes the balls to reach the ground below will be? (Ignore air resistance)*

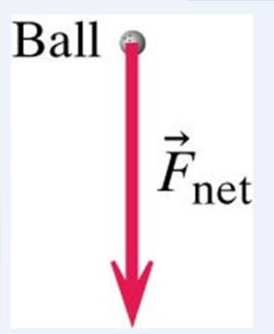
  (1) half as long for the heavier ball as for the lighter one.

  (2) half as long for the lighter ball as for the heavier one.

  (3) about the same for both balls.

  (4) considerably less for the heavier ball, but not necessarily half as long

  (5) considerably less for the lighter ball, but not necessarily half as long



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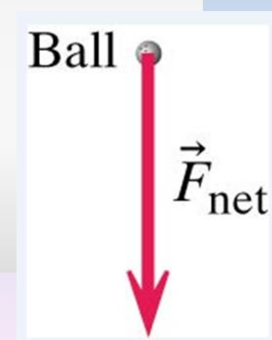

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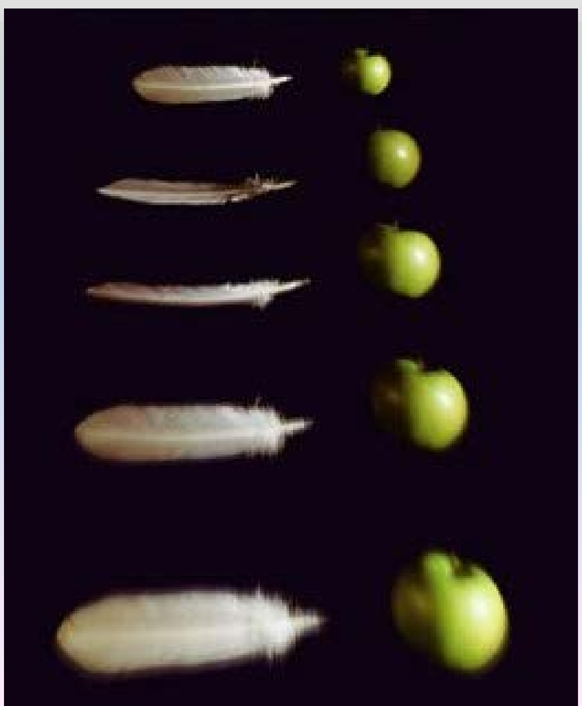
Coin and Feather Demo



Physics 2211: *Matter and Interactions*

NASA Glenn Research Center's Plum Brook Station in Sandusky, Ohio

Largest Vacuum chamber in the world: measures 100 feet in diameter and is a towering 122 feet tall

Can the Momentum principle help us to understand this????

Physics 2211: *Matter and Interactions*

- **The momentum principle (a special case)** **Constant Force!**

$$x(t)=\frac{1}{2}\left(\frac{F_{c,x}}{m}\right)t^2+(v_{x,0})t+x_0$$

$$y(t)=\frac{1}{2}\left(\frac{F_{c,y}}{m}\right)t^2+(v_{y,0})t+y_0$$

F_{gy}=mg; g= 9.8m/s^2

For Falling objects: $Y_f = Y_o + V_{oy}\, t + F_y t^2/2m$

$= Y_o + V_{oy}\, t - gt^2/2$ → What does this tells us?

All things fall the same way!!

They are independent of their mass

- **The momentum principle (a special case)** **Constant Force!**

$$x(t)=\frac{1}{2}\left(\frac{F_{c,x}}{m}\right)t^2+(v_{x,0})t+x_0$$

$$y(t)=\frac{1}{2}\left(\frac{F_{c,y}}{m}\right)t^2+(v_{y,0})t+y_0$$

F_{gy}=-mg; g= 9.8m/s^2

For Falling objects:

$$Y_f = Y_o + V_{oy}\, t + F_y t^2/2m$$
$$= Y_o + V_{oy}\, t - gt^2/2$$

Furthermore:

Time for an object of mass M to fall a distance Y is :

t = SQRT($2*Y*M/F_g$) = SQRT($2*Y/g$)

Independent of the mass!!

Dropping a bill and catching it challenge.

F=-mg

$$Y_f = Y_o + V_{oy}\, t + F_y t^2/2m$$

average reaction time t= 200-250 milliseconds

F_y=-mg.

Distance traveled in that time ~ 20 cm.

Example 3: 3 dimensional motion

Projectile motion

(no air resistance)

Q. If one ball is dropped out of the table and another is pushed very fast out of the table:

a) The dropped ball will reach the floor sooner
b) The pushed ball will reach the floor sooner
c) Both balls will reach the floor at the same time

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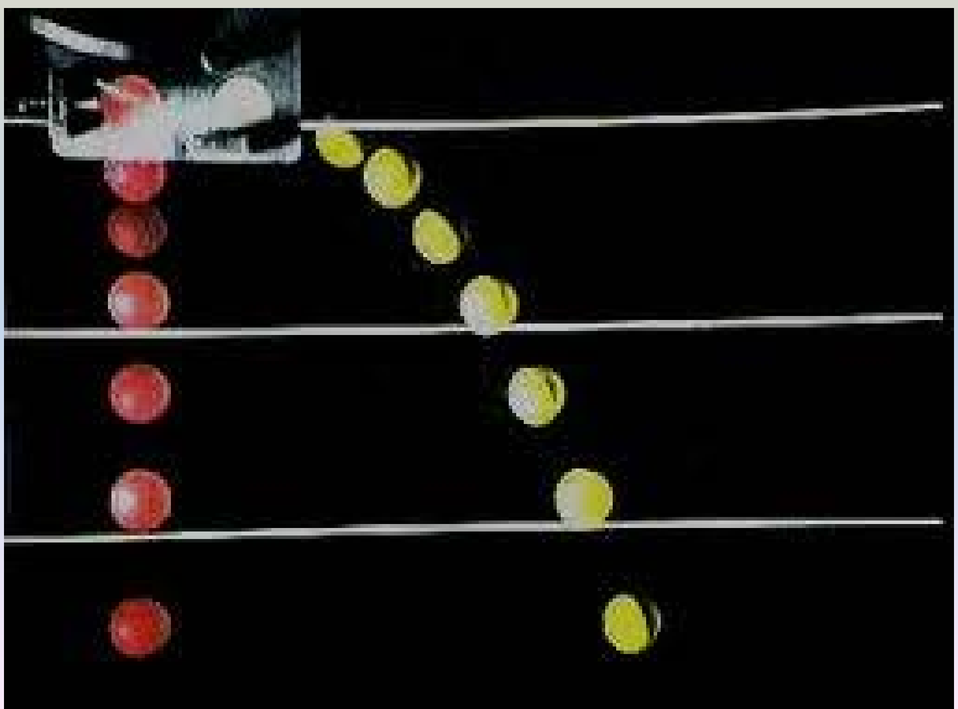


$$Y_f = Y_o + V_{oy}\, t - g t^2/2$$

0

$$X_f = X_o + V_{ox}\, t - \cancel{Ft^2/2m}$$

What happens if instead of looking at this experiment from the front we look at it from the side?

- **The momentum principle (a special case)** **Constant Force!**

$$x(t)=\frac{1}{2}\left(\frac{F_{c,x}}{m}\right)t^2+(v_{x,0})t+x_0$$

$$y(t)=\frac{1}{2}\left(\frac{F_{c,y}}{m}\right)t^2+(v_{y,0})t+y_0$$

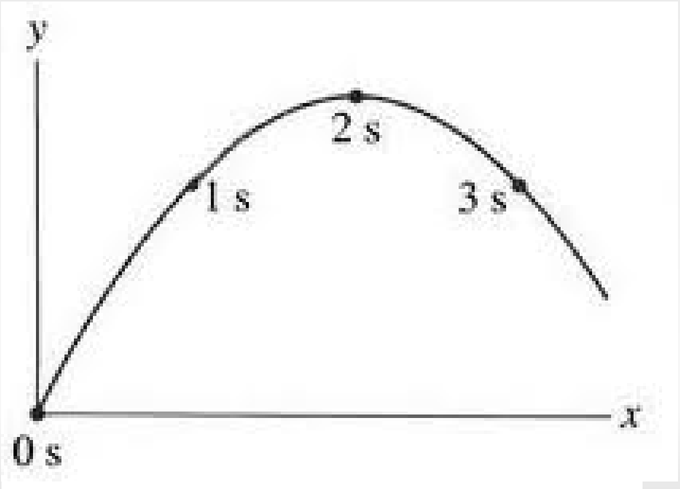
$F_g=mg$; $g= 9.8 m/s^2$

- **Projectile motion:**

no air resistance

$$x(t)=(v_{x,0})t+x_0$$

$$y(t)=\frac{1}{2}(-g)t^2+(v_{y,0})t+y_0$$



How is the force? Constant value the whole time

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$$x(t)=\frac{1}{2}\left(\frac{F_{c,x}}{m}\right)t^2+(v_{x,0})t+x_0$$

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- **Projectile motion:**

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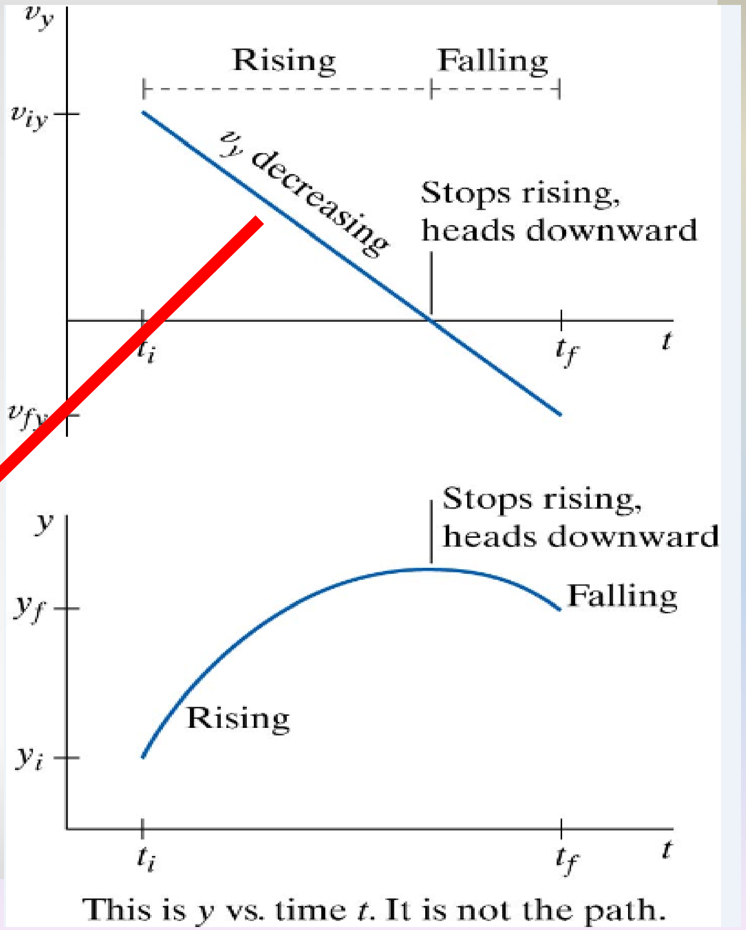


Note: Constant Force ➔ linear change in Velocity. So V_average = (Vi + Vf)/2 Arithmetic average

Remember what happens to one component is Independent to the other component

$$x(t)=\frac{1}{2}\left(\frac{F_{c,x}}{m}\right)t^2+(v_{x,0})t+x_0$$

$$y(t)=\frac{1}{2}\left(\frac{F_{c,y}}{m}\right)t^2+(v_{y,0})t+y_0$$

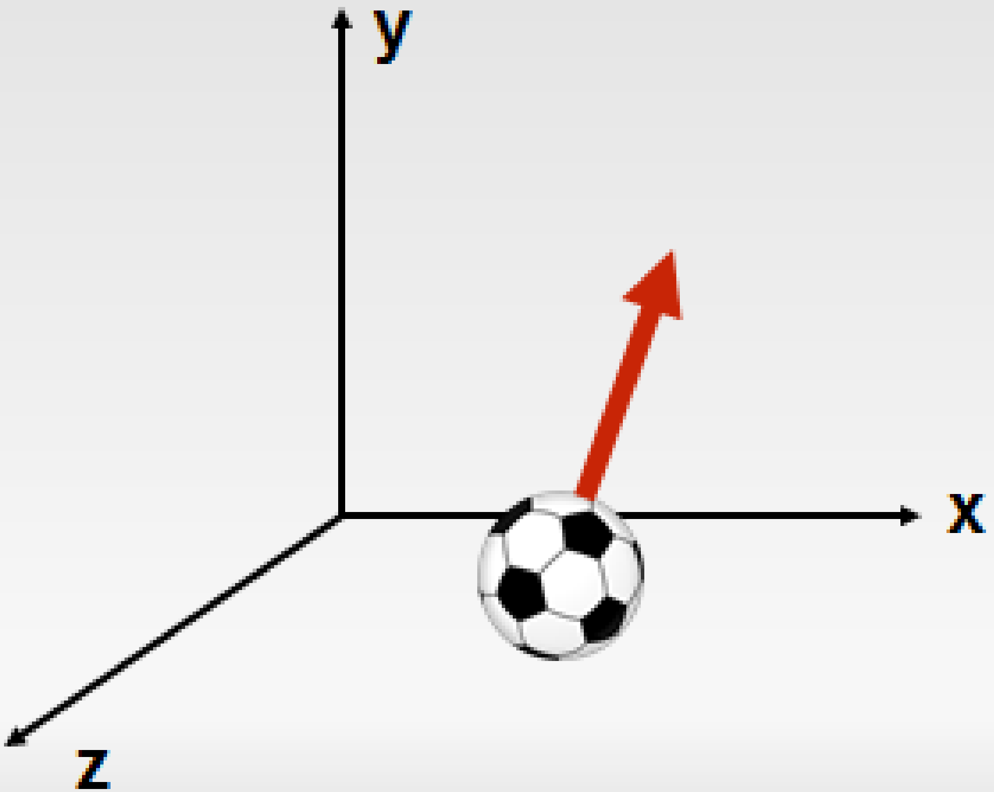
- **Projectile motion:**

$$\boxed{\begin{aligned} x(t)&=(v_{x,0})t+x_0 \\ y(t)&=\frac{1}{2}(-g)t^2+(v_{y,0})t+y_0 \end{aligned}}$$

Physics 2211: *Matter and Interactions*

Clicker: *A ball is initially on the ground, and you kick it with initial velocity < 3,7,0> m/s. At this speed air resistance is negligible. Assume the usual coordinate system. Which components of the ball's momentum will change in the* ***next*** *half second?*

(1) P_x
(2) P_y
(3) P_z
(4) P_x & P_y
(5) P_y & P_z
(6) P_z & P_x
(7) P_x, P_y, & P_z



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(1) P_x

(2) P_y

(3) P_z

(4) P_x & P_y

(5) P_y & P_z

(6) P_z & P_x

(7) P_x, P_y, & P_z