

## Lectures 21-23

### Chap. 11

### Properties of Materials

#### Classes of Materials:

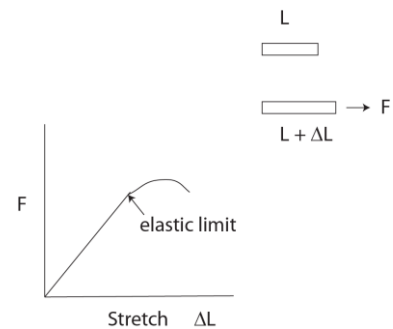
Solids --- fixed shape can be crystals (simple geometrical shape) or amorphous (glasses, plastics)

Liquids -- can flow, fill shape of container BUT incompressible

Gases --- compressible otherwise like liquids

#### Solids

- Can stretch
- $\Delta L$  proportional to  $F$  up to elastic limit (Hooke's law)



Stress =  $F/A$  ( $N/m^2$  OR Pascals abbrev. = Pa)

Strain =  $\Delta L/L$

Modulus of Elasticity = Stress/strain

YOUNG's Modulus  $Y = \frac{F/A}{\Delta L/L}$  typically a high number  $\sim 100$  GPa

## BULK Modulus

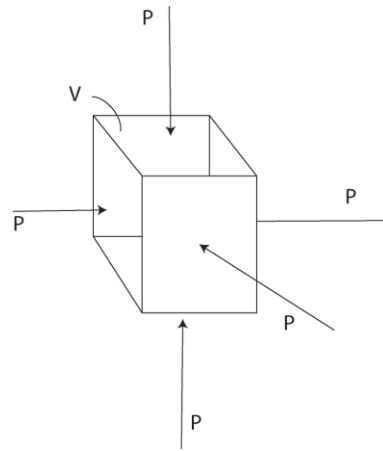
### Squeezing a 3D volume $V$

$V$  to  $V + \Delta V$

Stress =  $P$

Strain =  $-\Delta V/V$

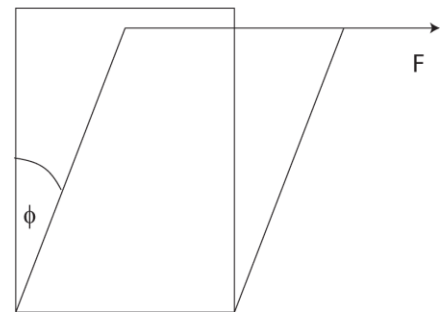
BULK Modulus  $B = \frac{P}{-\Delta V/V}$



## SHEAR

### SHEAR

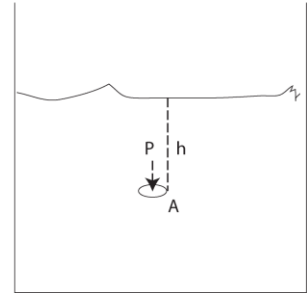
Shear Modulus  $B = \frac{F/A}{\Phi}$



Pressure at depth h in fluid

$$P = \rho gh$$

$\rho$  = density of fluid

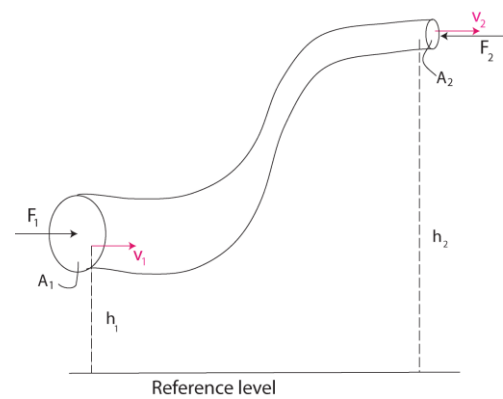


## Motion of fluids in pipes

Conservation of mass (fluid incompressible) and conservation of energy

$$\frac{1}{2} \rho v_1^2 + \rho gh_1 + P_1 = \frac{1}{2} \rho v_2^2 + \rho gh_2 + P_2$$

(Bernoulli's eq'n)



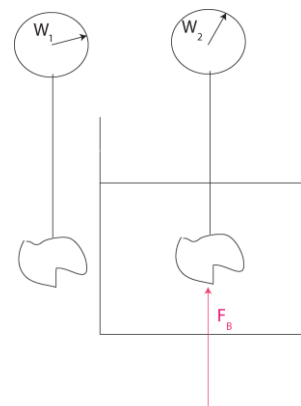
At point 1 height h1 above reference level

$v_1$  is velocity and  $P_1$  is pressure

## Buoyancy

Archimede's Principle

$$F_B = \text{weight of fluid displaced} = W_1 - W_2$$



PHY 2004

Lectures 16-20

## MOMENTUM

### Collision

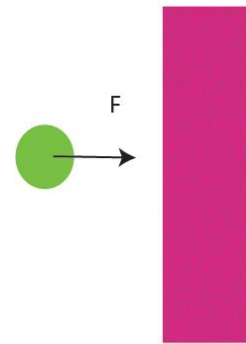
Impulse  $I = F t$

$$F = ma = m(V_f - V_i)/t$$

Hence:

$$I = mV_f - mV_i$$

**Momentum  $P = mV$**



NO impulse, no force, no collision

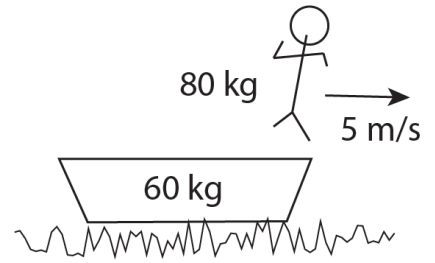
NO CHANGE IN MOMENTUM

called **conservation of momentum**

**Example:**

**You jump off a boat**

**Before jump  $P=0$**



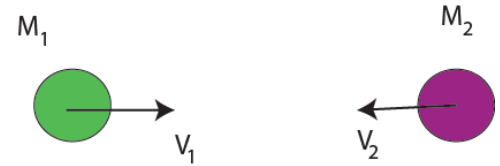
**Therefore, after jump  $P=0$**

$$P_{\text{after}} = P_{\text{Man}} + P_{\text{boat}}$$

$$\text{Therefore } P_{\text{boat}} = -P_{\text{man}} = -400 = M_{\text{boat}} V_{\text{boat}} = 60 V_{\text{boat}}$$

**THUS  $V_{\text{boat}} = -6.7$  m/s (minus sign means goes backward)**

## ELASTIC COLLISIONS



**Momentum initial = Momentum after**

$$M_1 V_1^{\text{init}} + M_2 V_2^{\text{init}} = M_1 V_1^{\text{after}} + M_2 V_2^{\text{after}}$$

**No energy losses, therefore**

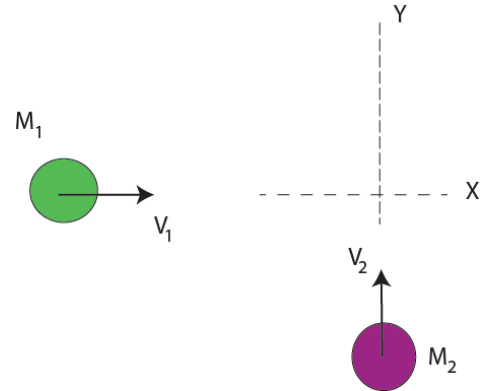
$$(1/2)M_1(V_1^{\text{init}})^2 + (1/2)M_2(V_2^{\text{init}})^2 = (1/2)M_1(V_1^{\text{after}})^2 + (1/2)M_2(V_2^{\text{after}})^2$$

**USE both equations can show;**

$$V_1^{\text{init}} + V_1^{\text{after}} = V_2^{\text{init}} + V_2^{\text{after}}$$

**USED often**

## Collisions in TWO Dimensions



**Separate momentum into components in X and Y direction**

**P total in X direction is constant**

**AND**

**P total in Y direction is constant**

## Chapter 9

### ANGULAR MEASUREMENTS

In time  $t$   
sweep out  $\theta$

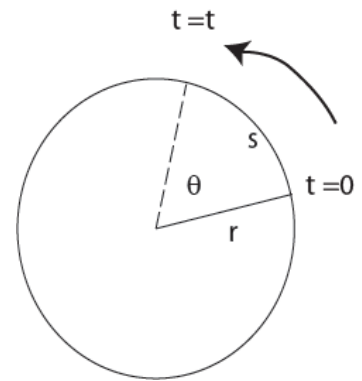
$$\theta = s/r$$

$\theta$  is in RADIANS

**1 Revolution = 360 degrees =  $2\pi$  radians**

### ANGULAR VELOCITY

$\omega = \theta/t$       radians / sec.

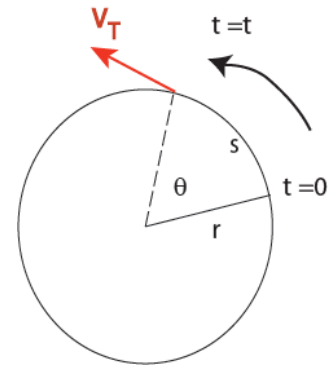


## TANGENTIAL VELOCITY

$$V_T = r\omega$$

$r$  must be in radians /sec.

$V_T$  is in m/s if  $r$  is in meters



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## CENTRIPETAL ACCELERATION

Tangential velocity is **CONSTANT**  
in magnitude

**BUT direction changes** by  $\Delta V$

**THEREFORE** there is an

**acceleration toward the center**

$$a_c = V_T^2 / r$$





## PLANETS

Constant angular speed  
(approximately)

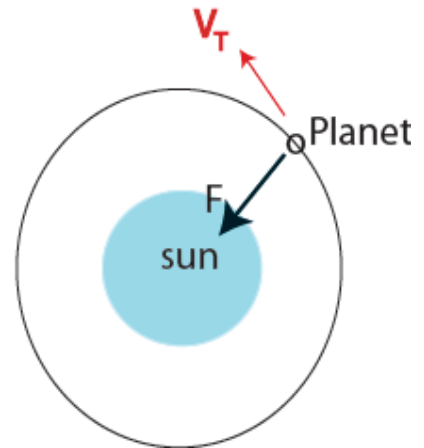
Centripetal acceleration =  $V_T^2/r$

Provided by gravitational force

$$F = GMm/r^2$$

HENCE

$$V_T = \sqrt{GM/r}$$



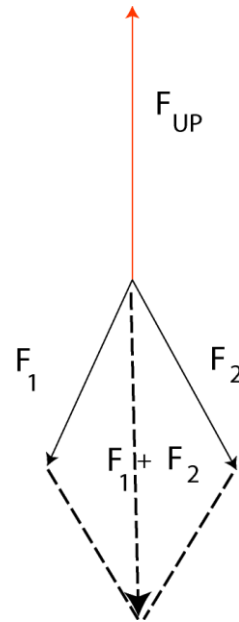
PHY 2004 LECTURES 10-12

EQUILIBRIUM Chapter 8.

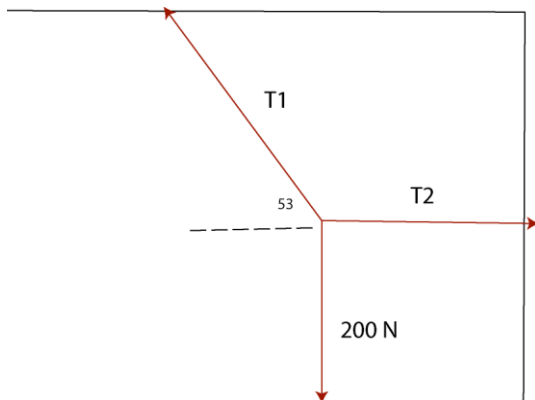
No motion ( OR constant motion i.e. no acceleration)

**Vector sum of forces = 0**

I.e. in figure to right  $F_1 + F_2 = F_{UP}$



In figure below,



Equilibrium requires

For horizontal direction;

$$T_1 = T_2 \cos 53 = 0.6T_2$$

For vertical direction;

$$T_2 \sin 53 = 200, \text{ OR } 0.8T_2 = 200$$

Solve  $T_1 = 150 \text{ N}$

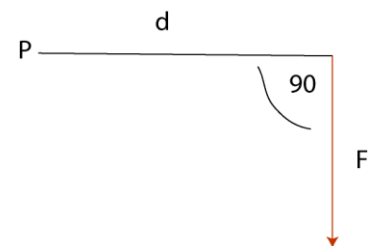
## Turning effect

Measure of turning or twisting (rotational or angular) motion

Torques must cancel

## Torque

$$\begin{aligned}\tau &= d * \text{perpendicular component of force to axis } d \\ &= dF\end{aligned}$$

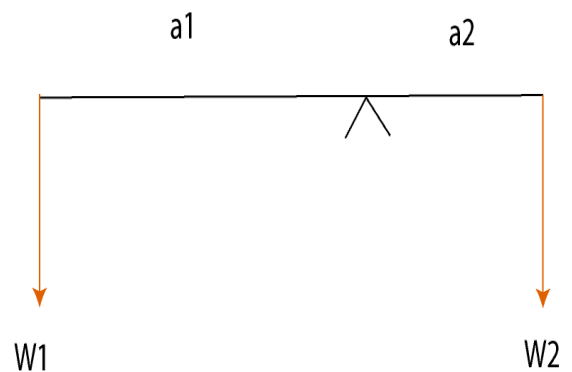


Has a sense of rotation about P: clockwise (+) or anticlockwise (-)

## Equilibrium:

**Sum of all torques about ANY point in system must =0**

E.g seesaw



Sum of torques =0

$$W1 * a1 + W2 * a2 = 0$$



## PHY 2004, Lectures 8-9

### ENERGY, WORK

#### Work

$$W = FxD.$$

D =distance in the same direction as the force

#### Work by gravity

$F=mg$  If move against gravity do positive work

$$W =mgh$$

This energy is stored, e.g placing a mass on a shelf at height  $h$

Can recover this POTENTIAL energy

Knock mass off shelf. Object gains KINETIC energy

$$\text{Use } V_f^2 = 2gh$$

to show final kinetic energy  $K = (1/2)mV^2$

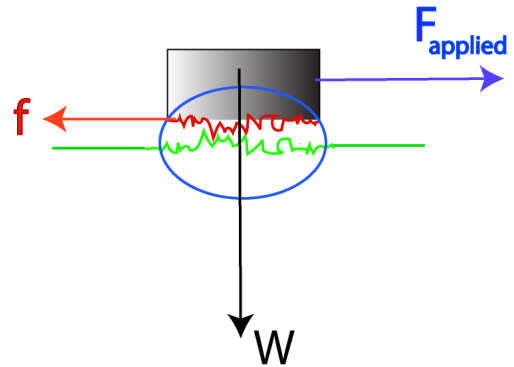
# LECTURE 7 PHY 2004

## FRICTION

Force of friction proportional  
to force NORMAL to motion

$\mu$  = coefficient of friction

$$f = \mu W$$



Rubber on concrete       $\mu \approx 0.8$

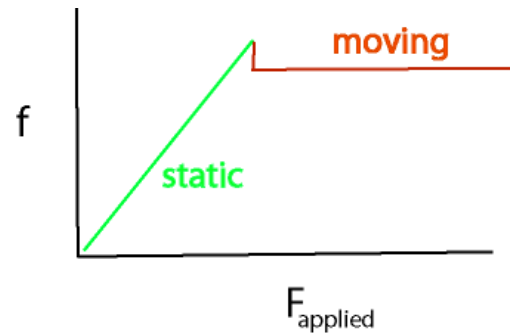
Steel on steel              0.07

Skater on ice              0.02

## Static versus sliding friction

Object does not move until

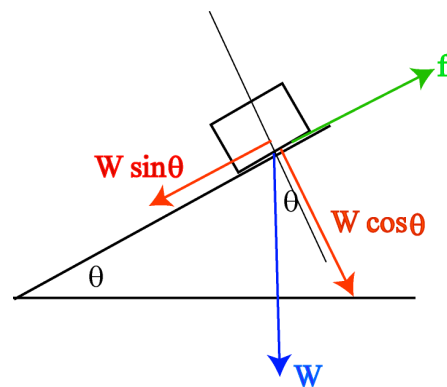
$F_{\text{applied}}$  overcomes static friction



## Inclined plane

Force normal to plane

$$F = W \cos \theta$$



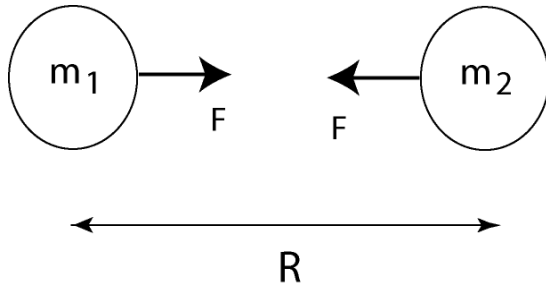
Friction  $f = \mu W \cos \theta$

SLIDES when  $W \sin \theta = f$

OR  $\tan \theta = \mu$

# LECTURE 6 [PHY 2004](#)

## Gravity



## Force

$$F = \frac{Gm_1m_2}{R^2}$$

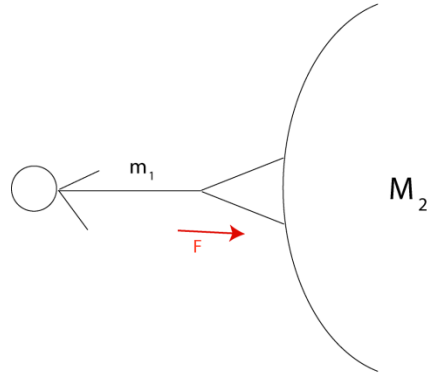
**G is universal constant**

**(same everywhere)**



# Weight

$$F = m_1 g = \frac{Gm_1m_2}{R^2}$$



**Thus**

$$g = \frac{Gm_2}{R^2} \quad \text{for mass on surface of planet } M_2$$

## Problem 3.41

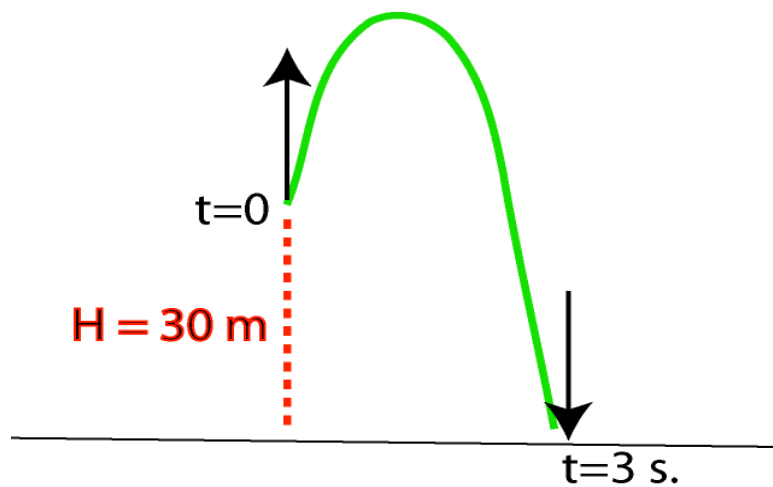
$$g(\text{moon}) = 1.6 \text{ m/s}^2$$

$$\text{Weight on moon} = 1.6(4) = 6.4 \text{ N}$$

$$\text{Weight on Earth} = 9.8(4) = 39.2 \text{ N}$$

# LECTURE 5 PHY 2004

Chap. 2 #43



$$Y = V_i t + (1/2)at^2 \quad \dots\dots\dots (1)$$

At end  $Y = -30 \text{ m}$  (below origin)

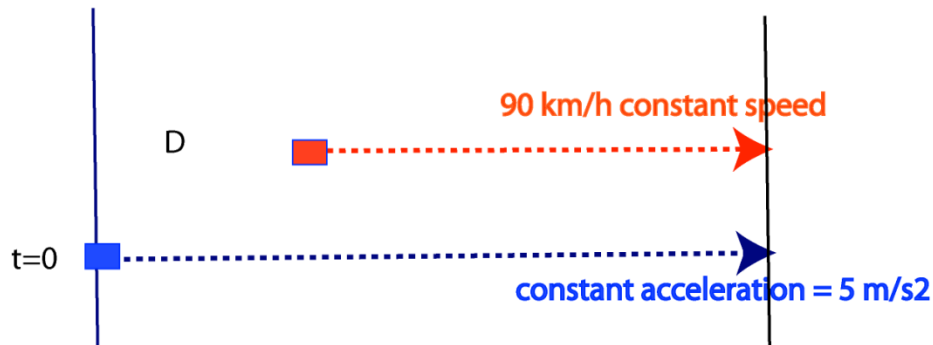
acceleration  $a = -g = -9.8 \text{ m/s}^2$

Put in Eq'n (1)

$$-30 = V_i 3 - (1/2)(9.8) 9$$

$$V_i = (4.9)3 = 4.7 \text{ m/s}$$

## Chap 2. # 35



Red speed constant =  $90 \text{ km/h} = 25 \text{ m/s}$

Blue does not start until 5 seconds after red passes,  $D=(5)(250)=125 \text{ m}$

Need to find  $t$ , then calculate distances

NOTE:  $X_{\text{blue}} = X_{\text{red}} + 125$  .....Eq'n (1)

$$X_{\text{red}} = 25 t$$

$$X_{\text{blue}} = (1/2) a t^2 = (1/2) 5 t^2 = 2.5 t^2$$

Use Eq'n (1)

$$2.5 t^2 = 25 t + 125, \text{ or}$$

$$t^2 = 10 t + 50,$$

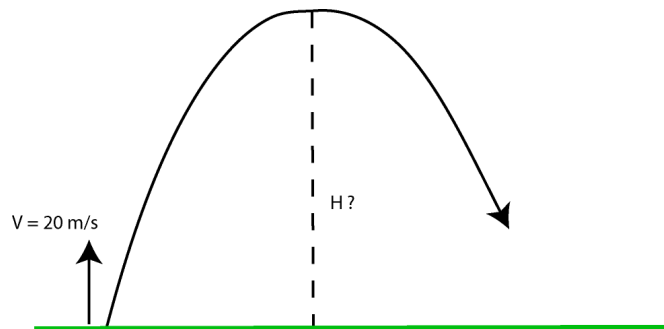
$$\text{or } t = 5 \pm \sqrt{(75)} \text{ ( -ve sign non-physical)} = 5 + 8.7 = 13.7 \text{ s}$$

$$X_{\text{red}} = 25 t = 341.5 \text{ m}$$

$$X_{\text{blue}} = 466.5 \text{ m}$$

# LECTURE 3 PHY 2004

Gravity constant at Earth's surface (always "down")



## Typical problem

Throw ball up at 20 m/s. How high will it go?

$$V_F^2 = V_i^2 + 2aH$$

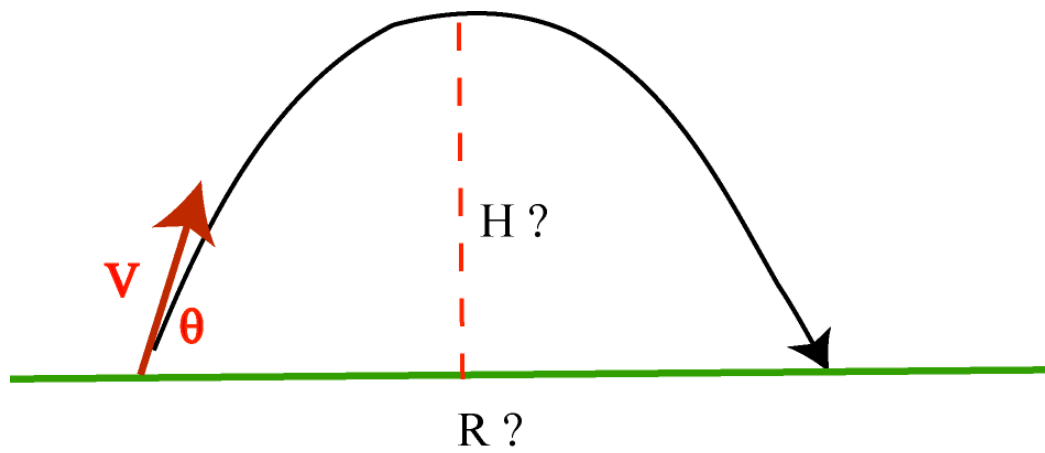
$a = -9.8 \text{ m/s}^2$  ( gravity **DOWN** deceleration )

$$V_F = 0$$

$$0 = 20^2 - 2(9.8)H$$

$$H = 400/19.6 = 20.4 \text{ m}$$

## Projectile Motion



Initial velocity  $V$  at angle  $\theta$  to horizontal

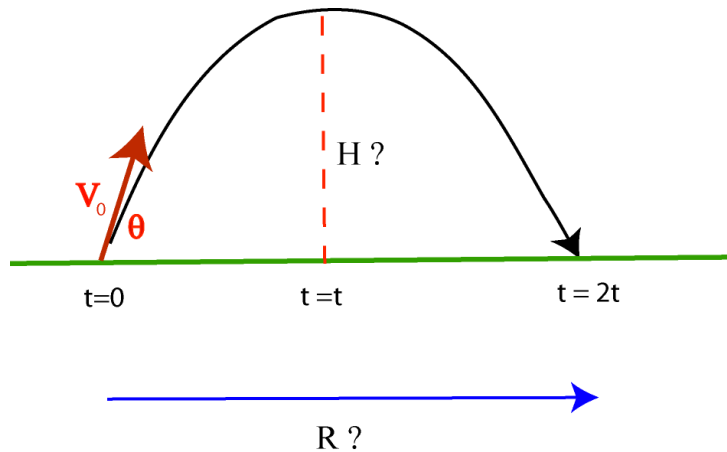
Calculate  $R$

Calculate  $\theta$

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# LECTURE 4 PHY 2004

Continuing the above problem from lecture 3.



Key point to remember, the x and y motions are independent.

Resolve  $V$  into x and y motions

$$V_x = V_0 \cos\theta$$

$$V_y = V_0 \sin\theta$$

Consider vertical motion.  $V_y = 0$  at top where  $y = H$

$$V_{\text{avg}} \text{ (y-direction)} = (1/2) V_0 \sin\theta$$

At top use  $V_f = V_i + at$ , or  $0 = V_0 \sin\theta - gt$  which gives  $t = (V_0 \sin\theta)/g$

$$H = V_{\text{avg}} \cdot t = (1/2) V_0 \sin\theta \cdot (V_0 \sin\theta / g)$$

No need to memorize this formulae,  
just remember simple red equations

$$R = (\text{total time}) V_x = 2t V_0 \cos\theta$$

## **PHY 2004:** *Applied Physics in our world today*



**Neil S. Sullivan** *Fall 2010*

**NPB Rm 2235**

**Email:** [sullivan@phys.ufl.edu](mailto:sullivan@phys.ufl.edu)

**Tel.** 352-846-3137

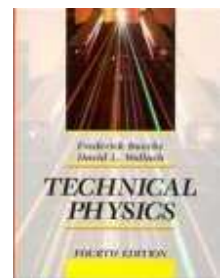
**Class meets:** M W F (Period 8) 3:00 -3:50 PM

**NPB 1001**

**Office Hours:** M W F (Period 4) 10:40 – 11:30 AM

**NPB 2235**

**Textbook:**



*Technical Physics*

**F. Bueche & D. Wallach**  
(4<sup>th</sup> ed., J. Wiley & Sons, 1994)

## **PHY 2004**

### **GENERAL POINTS**

Reference materials, important dates: **CHECK** [course web site](#)

### **Course Goals**

General introduction to use of physics in **everyday life**

Simple applications, useful in professional careers

Emphasis on principles (not lengthy calculations)

### **Exams:**

Some problems in exams will be from problems

discussed in class and in in-class quizzes (clicker responses)

Make-up exams (date TBD) Need SIGNED documentation  
from Dr. coach teacher etc.

### **HITT:**

Have remotes by September 7 (to have in-class quizzes recorded)



## **PHY 2004 Exams Fall 2010**

**All here in NPB 1001**

**Mid-term: Best two 30 points each**

- 1. Sept. 20 Pd 8 (3-3:50 PM)**
- 2. Oct. 20 Pd 8 (3-3:50 PM)**
- 3. Nov. 19 Pd 8 (3-3:50 PM)**
- 4.**

**Final Dec. 13 (3-5 PM) 40 points**

**unless third midterm better than final in which case**

**final =30 points and other mid-term=10 points)**

**In class questions = bonus of 5 %**

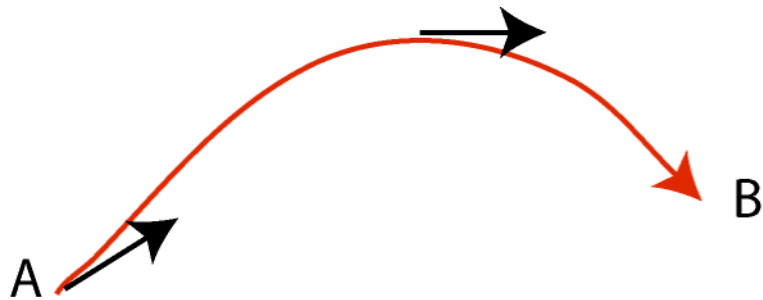


# LECTURE 2 PHY 2004

## MOTION

Speed (scalar) distance per unit time **meters/sec**

Velocity (vector) speed + direction



Direction different at different points

Average velocity = displacement vector AB/time

## Acceleration (vector)

Rate of change of velocity

$$a = (V_F - V_I)/t \quad \text{OR} \quad V_F = V_I + at$$

Uniform acceleration (typical in this class)

e.g. gravity, rockets

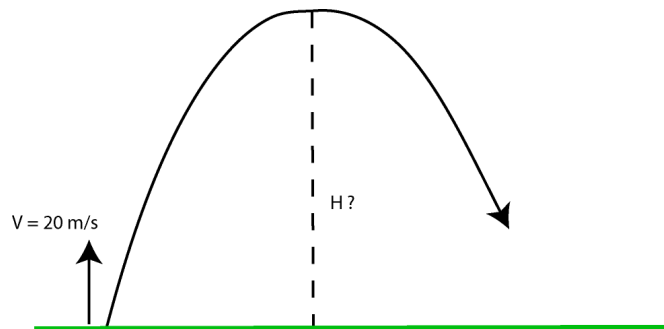
$$X = V_{\text{avg}} t \quad \text{where } V_{\text{avg}} \text{ is average velocity } V_{\text{avg}} = (V_I + V_F)/2$$

$$\text{THUS } X = (V_F^2 - V_I^2)/2a \quad \text{OR} \quad V_F^2 = V_I^2 + 2aX$$

$$\text{ALSO } X = V_{\text{avg}} t \quad \text{OR} \quad X = V_I t + (1/2)at^2$$

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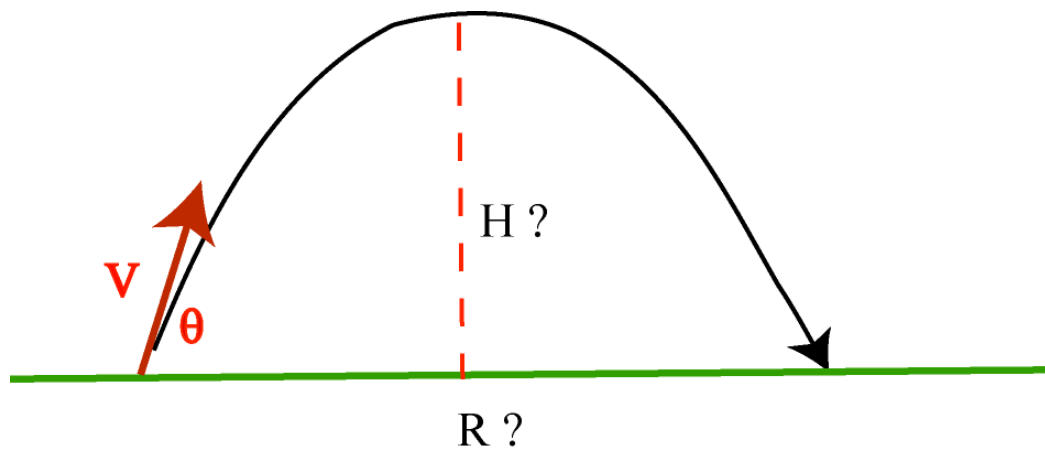
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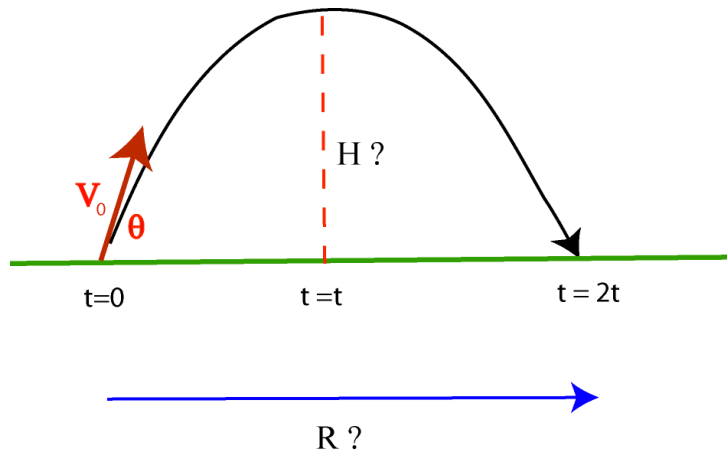
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