

PHY 2004

Lectures 16-20

MOMENTUM

Collision

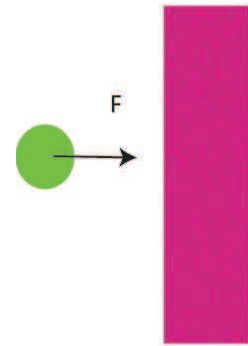
$$\text{Impulse } I = F t$$

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

Hence:

$$I = mV_f - mV_i$$

$$\text{Momentum } P = mV$$



NO impulse, no force, no collision

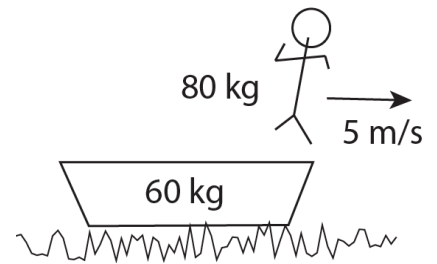
NO CHANGE IN MOMENTUM

called **conservation of momentum**

Example:

You jump off a boat

Before jump $P=0$



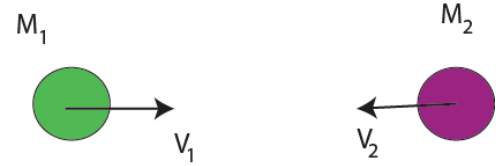
Therefore, after jump $P=0$

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

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

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

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

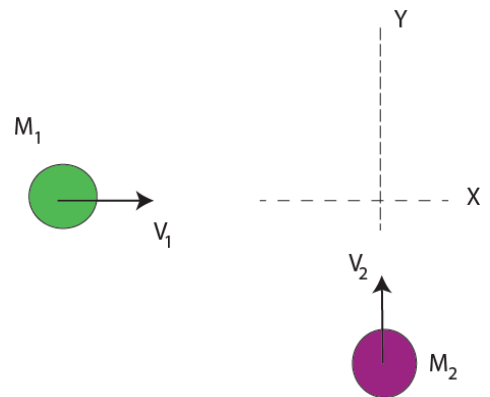
USE both equations can show;

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

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 θ

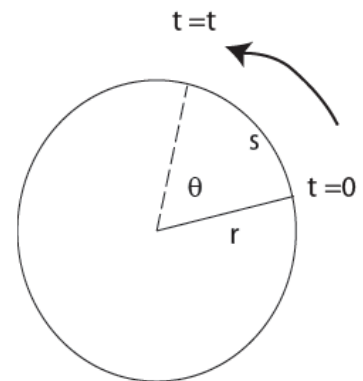
$$\theta = \frac{s}{r}$$

θ is in RADIANS

1 Revolution = 360 degrees = 2π radians

ANGULAR VELOCITY

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

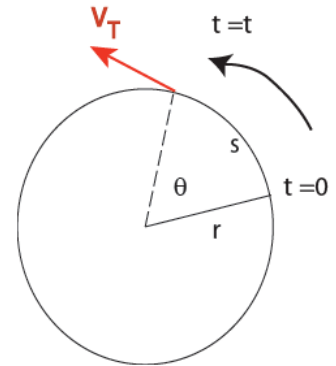


TANGENTIAL VELOCITY

$$V_T = r\omega$$

r must be in radians /sec.

V_T is in m/s if r is in meters



CENTRIPETAL ACCELERATION

Tangential velocity is **CONSTANT**
in magnitude

BUT direction changes by ΔV

THEREFORE there is an

acceleration toward the center

$$a_c = V_T^2 / r$$



PLANETS

Constant angular speed
(approximately)

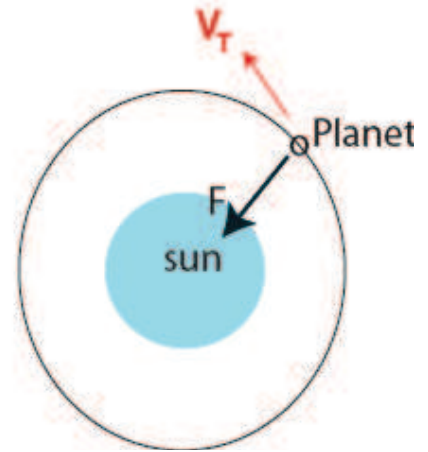
$$\text{Centripetal acceleration} = v_T^2/r$$

Provided by gravitational force

$$F = GMm/r^2$$

HENCE

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



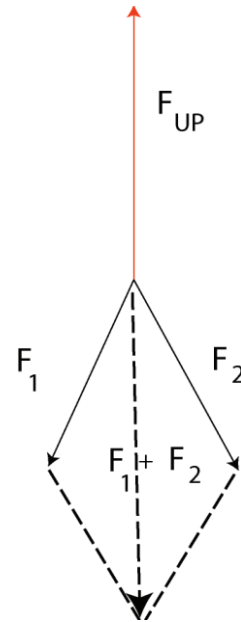
PHY 2004 LECTURES 10-12

EQUILIBRIUM Chapter 8.

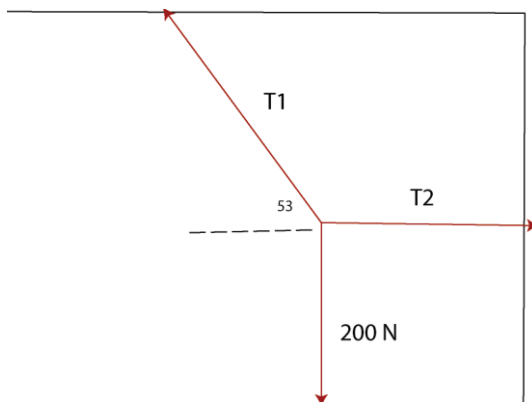
No motion (OR constant motion i.e. no acceleration)

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

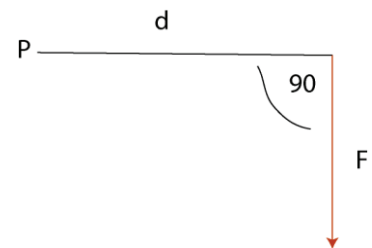
Measure of turning or twisting (rotational or angular) motion

Torques must cancel

Torque

$\tau = d * \text{perpendicular component of force to axis } d$

$$= dF$$

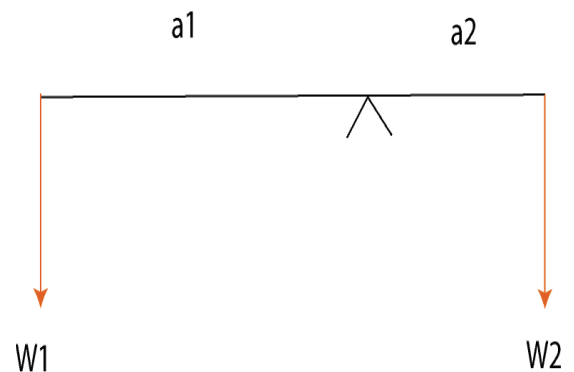


Has a sense of rotation about P: clockwise (+) or anticlockwise (-)

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 $K = (1/2)mV^2$

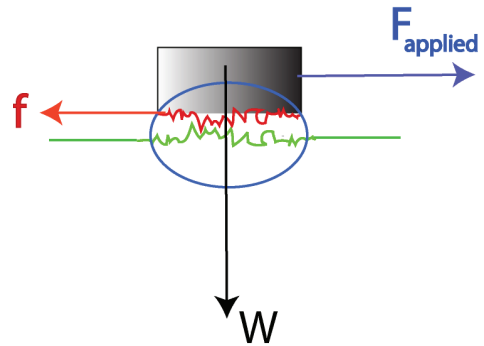
LECTURE 7 PHY 2004

FRICTION

Force of friction proportional
to force **NORMAL** to motion

μ = coefficient of friction

$$f = \mu W$$



Rubber on concrete $\mu \approx 0.8$

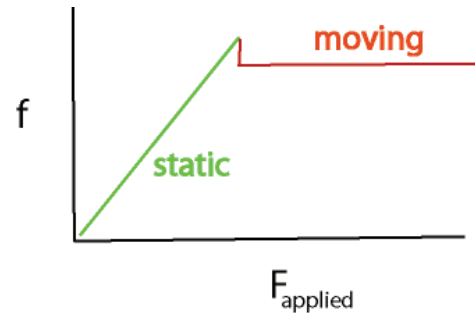
Steel on steel **0.07**

Skater on ice **0.02**

Static versus sliding friction

Object does not move until

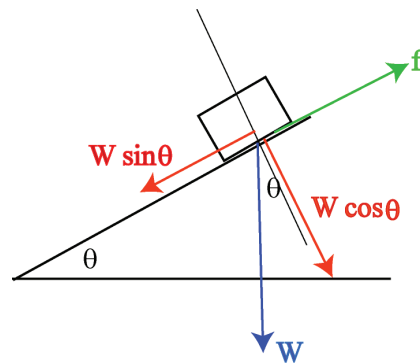
F_{applied} overcomes static friction



Inclined plane

Force normal to plane

$$F = W \cos \theta$$



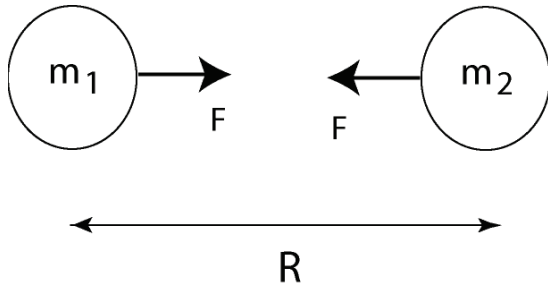
Friction $f = \mu W \cos \theta$

SLIDES when $W \sin \theta = f$

OR $\tan \theta = \mu$

LECTURE 6 PHY 2004

Gravity



Force

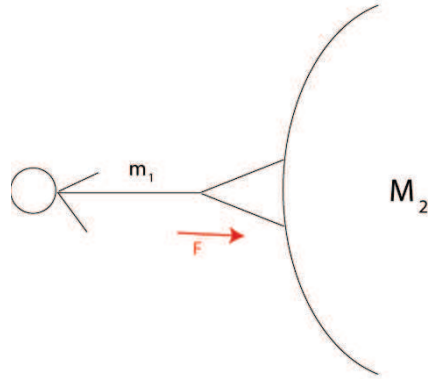
$$F = \frac{Gm_1m_2}{R^2}$$

G is universal constant

(same everywhere)

Weight

$$F = m_1 g = \frac{Gm_1 m_2}{R^2}$$



Thus

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

Problem 3.41

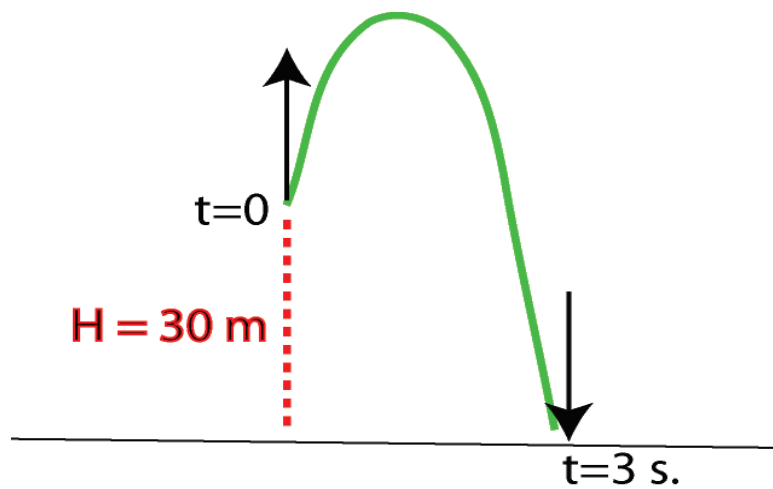
$$g(\text{moon}) = 1.6 \text{ m/s}^2$$

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

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

LECTURE 5 PHY 2004

Chap. 2 #43



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

At end $Y = -30$ m (below origin)

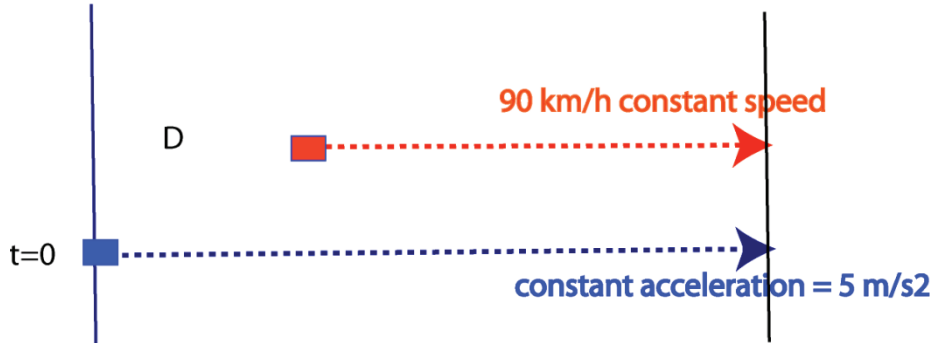
acceleration $a = -g = -9.8 \text{ m/s}^2$

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)

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

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

Use Eq'n (1)

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

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

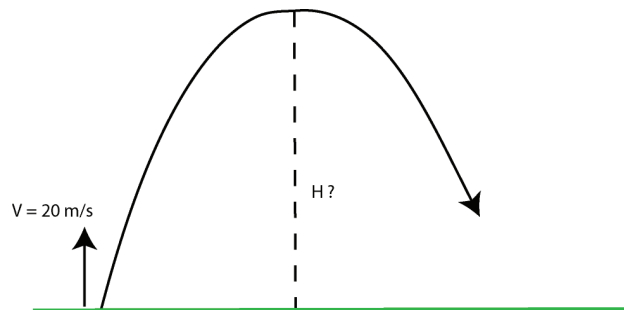
$$\text{or } t=5 \pm \sqrt{(75)} \text{ (-ve sign non-physical)}=5 + 8.7 = 13.7\text{s}$$

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

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

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?

$$V_f^2 = V_i^2 + 2aH$$

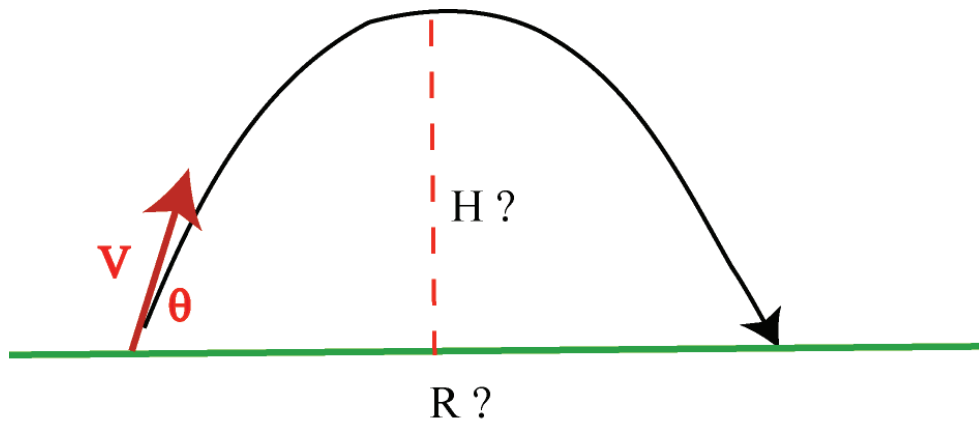
$a = -9.8 \text{ m/s}^2$ (gravity **DOWN** deceleration)

$$V_f = 0$$

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

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

Projectile Motion



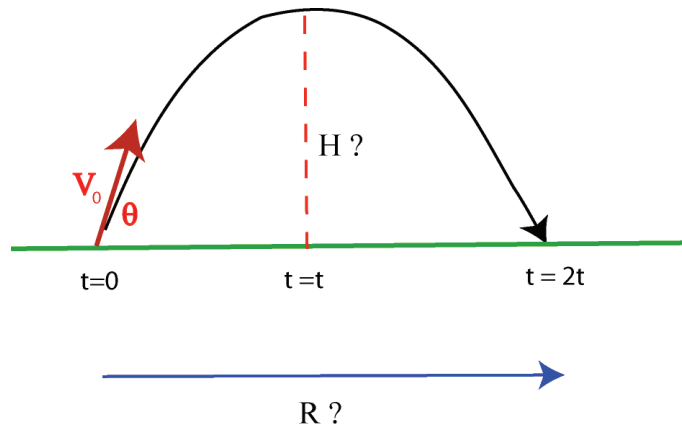
Initial velocity V at angle θ to horizontal

Calculate R

Calculate θ

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

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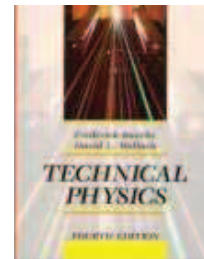
Class meets: M W F (Period 8) 3:00 -3:50 PM

NPB 1001

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

NPB 2235

Textbook:



Technical Physics

F. Bueche & D. Wallach
(4th 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)

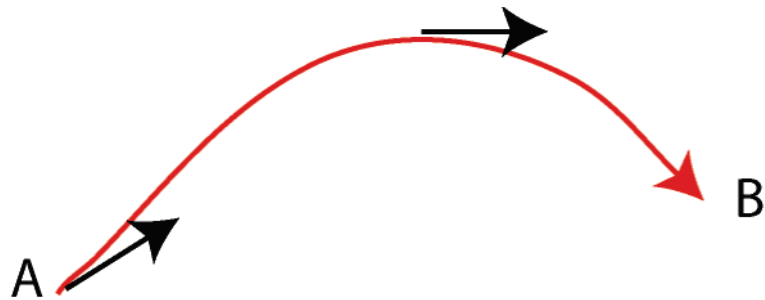
In class questions = bonus of 5 %

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

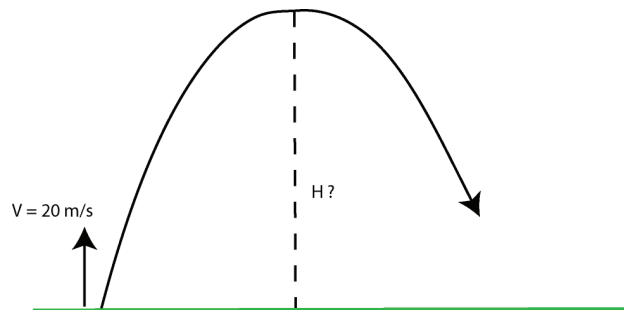
$$X = V_{\text{avg}} t \quad \text{where } V_{\text{avg}} \text{ is average velocity } V_{\text{avg}} = (V_I + V_F)/2$$

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

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

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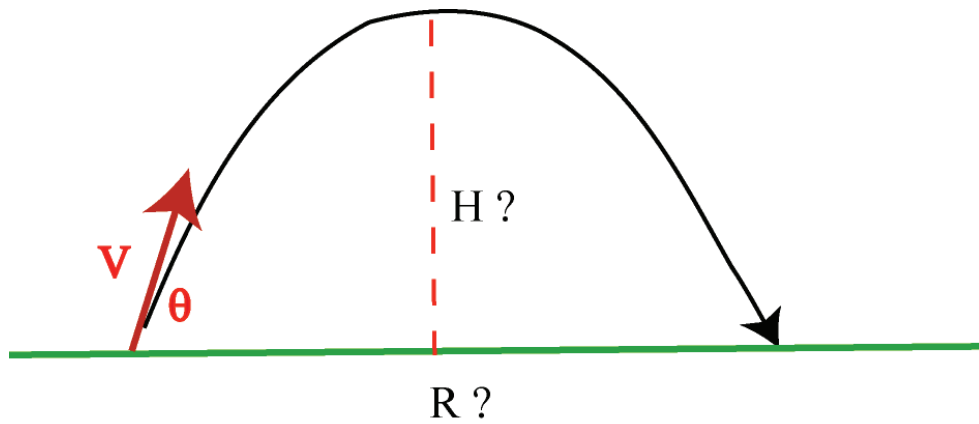
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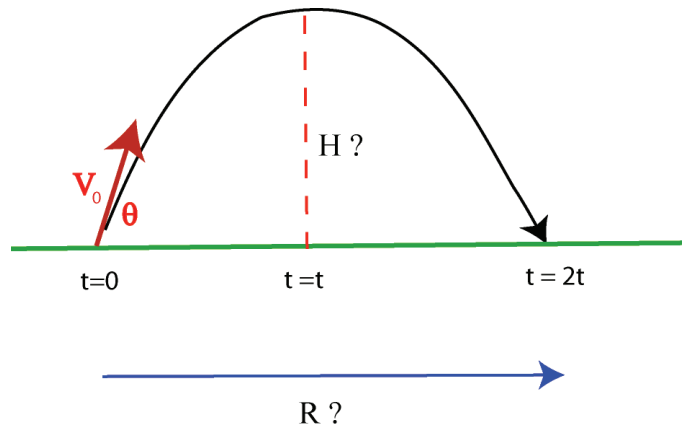
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