Chap. 15

Heat Transfer

Conduction

Rate of transfer of heat (Joules/second or Watts)

$Q/t = kA\Delta T/L$, A is the cross-sectional area ΔT is the change on temperature form one end to the other, and L is the length in m

k is the thermal conductivity of the material (units are J/m.K)

Convection

Surface of area A separates two regions that differ in temperature by ΔT

Rate of heat transfer (in Watts) $Q/t = hA\Delta T$ h is the convective surface coefficient

Radiation

Surface radiates heat by radiation (only process for vacuum or outer space)

$Q/t= e\sigma AT^4$ σ is the Stefan-Boltzmann constant = $5.67 * 10^{-8}$ ($W/m^2.K^4$)

A is the area in m^2

e is the emissivity of the surface e=1 for perfect heat emitter

Chap 14.

Thermodynamics

Conservation of energy

Heat into a system

$\Delta Q = \Delta U + W$ where ΔU is change in internal energy (only a function of temperature) and W is work on the OUTSIDE

Expansion at constant pressure, Work $W= P\Delta V$

Isochoric process V=constant $\Delta Q = \Delta U$

Isothermal process T = constant $\Delta U = 0$, $\Delta Q = W$

Adiabatic process (no heat change) $\Delta Q=0$, $\Delta U = - W$, e.g adiabatic expansion leads to cooling (ΔU is negative)

Heat engine

$\color{green}{\text{Efficiency} = W/\Delta Q_{IN}}$ where ΔQ_{IN} is the heat input and W is the work done by the machine on the outside

For an ideal system $W = \Delta Q_{IN} - \Delta Q_{out}$ and the efficiency $= 1 - \Delta Q_{out} / \Delta Q_{IN}$

For a Carnot cycle, the efficiency = $1 - T_{cold}/T_{hot}$

Chap 13.

Heat Energy

Specific heat C = heat to raise mass m by temperature change ΔT.

$C = (\Delta Q)/(m\Delta T)$ or $\Delta Q = mC\Delta T$ Units of C are J/kg K

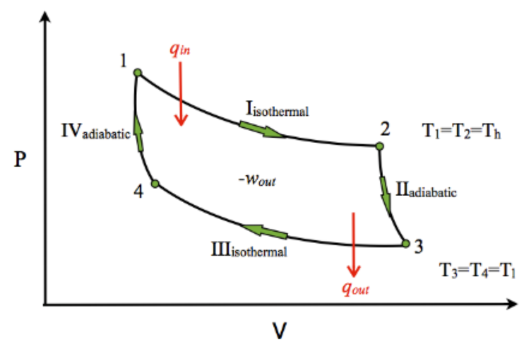
Latent heats

Heat to melt a solid of mass m

$\Delta Q = mL_M$ L_M is latent heat of melting (J/kg)

Heat to evaporate a liquid of mass m

$\Delta Q = mL_F$ L_F is latent heat of evaporation



Chap. 12

Temperature and Matter

Absolute temperature scale, Kelvin = Celsius + 273

Ideal Gas Law

PV = nRT

P in Pascals, V in m^3, T in Kelvin

n= number of kilomoles R= gas constant =8314 J/kmole/K

ALSO PV = (m/M) RT m= mass of gas, M=molecular weight (kmole)

Kinetic theory of gases

$(1/2)\ mV^2 = (3/2)\ kT$ v = mean sped of a molecule of mass m

k= Boltzmann's constant = $1.38 * 10^{-27}$ J/ K

Thermal expansion

Change in length for change in temperature ΔT

$\Delta L = \alpha L\ \Delta T$ α is coefficient of linear expansion

Lectures 21-23

Chap. 11

Properties of Materials

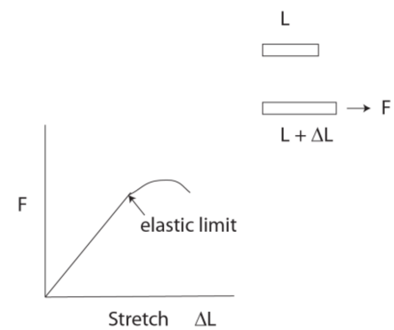
Classes of Materials:

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
- ΔL proportional to F up to elastic limit (Hooke's law)

Stress = F/A (N/m2 OR Pascals abrrev. = Pa)

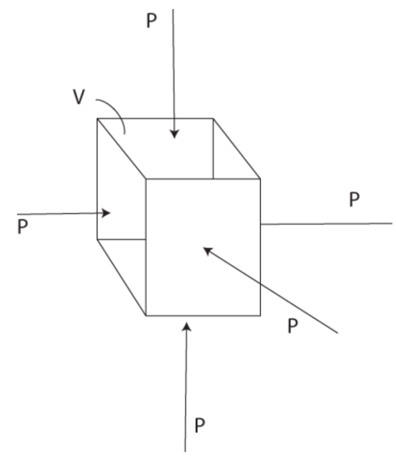
Strain =DL/L

Modulus of Elasticity = Stress/strain

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

BULK Modulus

Squeezing a 3D volume V

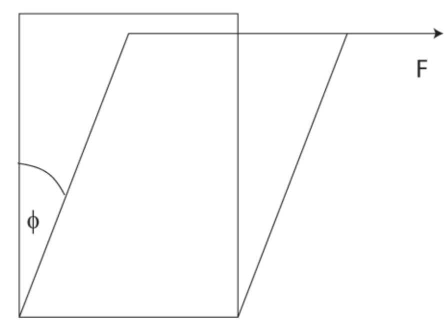


V to V + ΔV

Stress = P

Strain = - ΔV/V

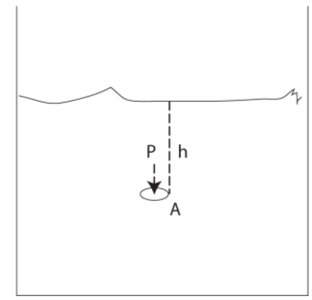
BULK Modulus $B = \frac{P}{-\Delta V / V}$



SHEAR

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

Pressure at depth h in fluid

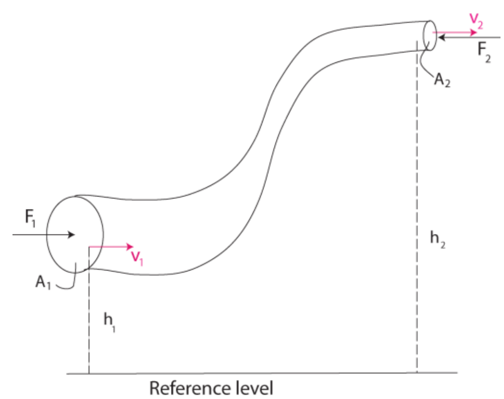


$P = \rho gh$

ρ = density of fluid

Motion of fluids in pipes

Conservation of mass (fluid incompressible) and conservation of energy



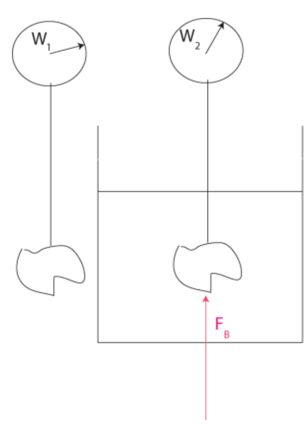
$$\frac{1}{2}\rho v_1{}^2 + \rho gh_1 + P_1 = \frac{1}{2}\rho v_2{}^2 + \rho gh_2 + P_2$$

(Bernouillis's eq'n)

At point 1 height h1 above reference level

V_1 is velocity and P_1 is pressure

Buoyancy



Archimede's Principle

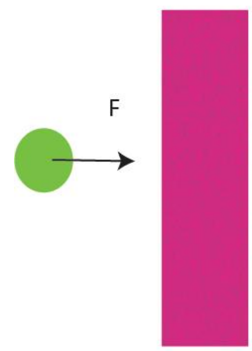
F_B = weight of fluid displaced = $W_1 - W_2$

PHY 2004

Lectures 16-20

MOMENTUM

Collision



Impulse $I = F\,t$

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

Hence:

$I = mV_f - mV_i$

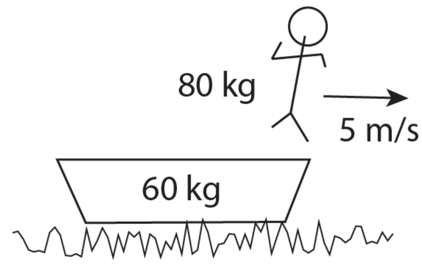
Momentum $P = mV$

NO impulse, no force, no collision

NO CHANGE IN MOMENTUM

called conservation of momentum

Example:



You jump off a boat

Before jump P=0

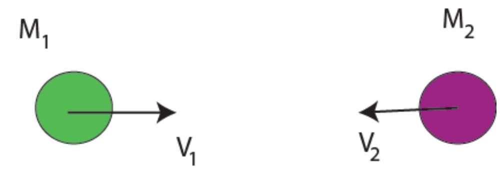
Therefore, after jump P=0

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

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

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

ELASTIC COLLISIONS



Momentum initial = Momentum after

$$M_1V_1^{Init} + M_2V_2^{Init} = M_1V_1^{after} + M_2V_2^{after}$$

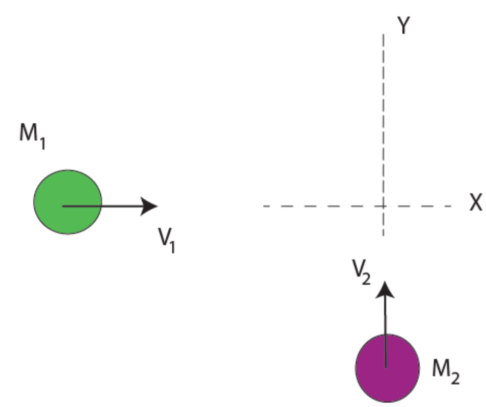
No energy losses, therefore

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

USE both equations can show;

$$V_1^{Init} + V_1^{after} = V_2^{Init} + V_2^{after}$$

USED often



Collisions in TWO Dimensions

Separate momentum into components in X and Y direction

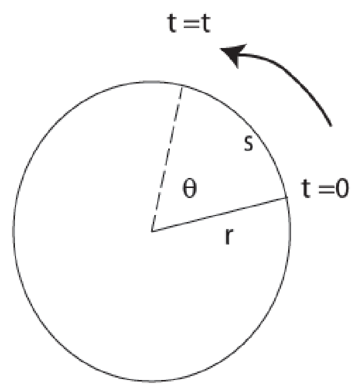
P total in X direction is constant

AND

P total in Y direction is constant

Chapter 9

ANGULAR MEASUREMENTS



In time t

sweep out θ

$\theta = s/r$

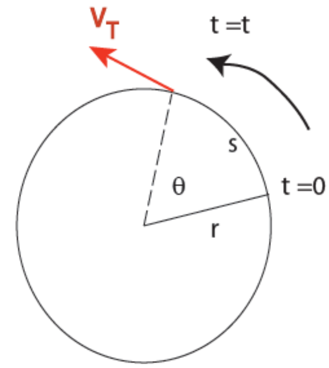
θ is in RADIANS

1 Revolution = 360 degrees =2π radians

ANGULAR VELOCITY

ω = θ/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

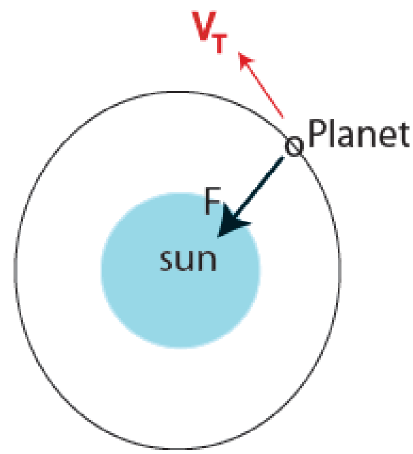
BUT <u>direction changes</u> by ΔV

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

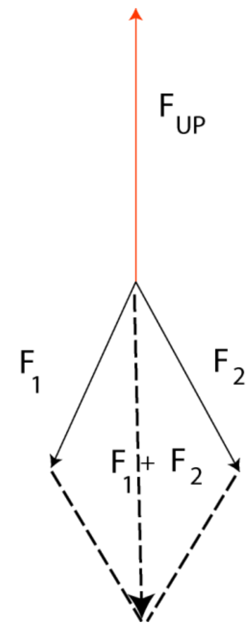
$F=GMm/r^2$

HENCE

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

PHY 2004 LECTURES 10-12

EQUILIBRIUM Chapter 8.

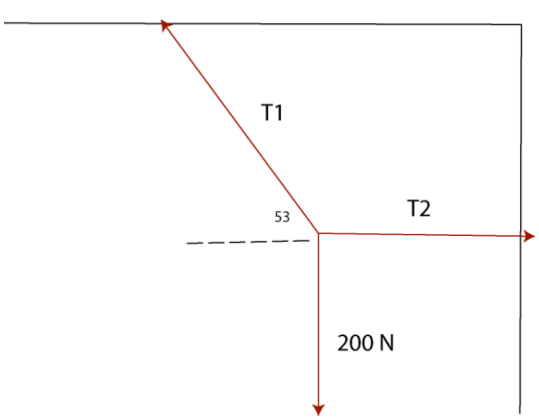


No motion (OR constant motion i.e. no acceleration)

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;

$$T1 = T2 \cos 53 = 0.6T2$$

For vertical direction;

$$T2 \sin 53 = 200, \quad \text{OR} \quad 0.8T2 = 200$$

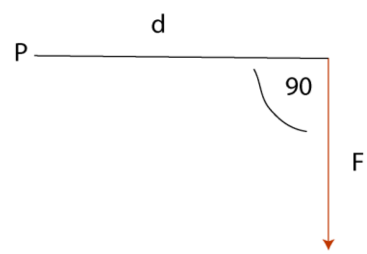
Solve T1= 150 N

Turning effect

Measure of turning or twisting (rotational or angular) motion

Torques must cancel

Torque



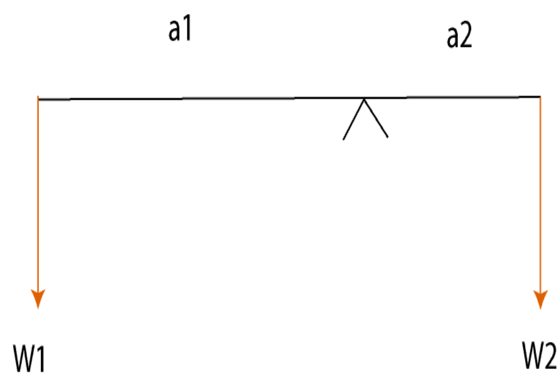
τ = d * perpendicular component of force to axis d

= 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

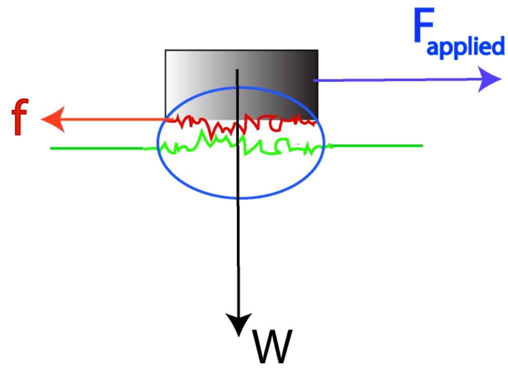
Knock mass off shelf. Object gains KINETIC energy

Use $V_F^2 = 2gh$

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

LECTURE 7 PHY 2004

FRICTION

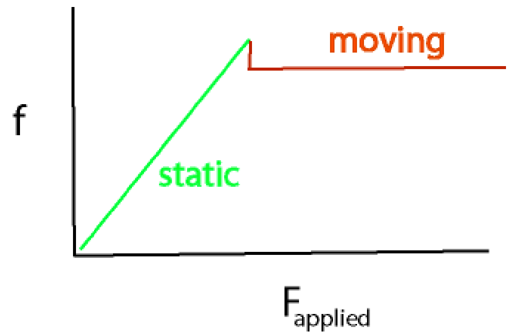


Force of friction proportional to force NORMAL to motion

μ = coefficient of friction $f=\mu W$

Rubber on concrete	$\mu \approx 0.8$
Steel on steel	0.07
Skater on ice	0.02

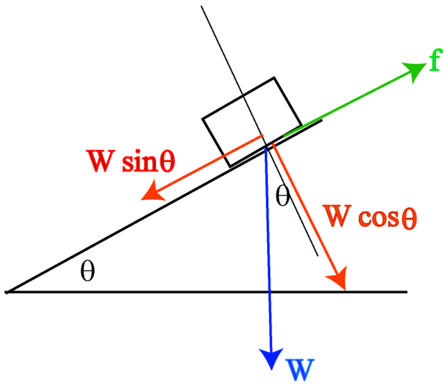
Static versus sliding friction



Object does not move until

$F_{applied}$ overcomes static friction

Inclined plane



Force normal to plane

$F = W\cos\theta$

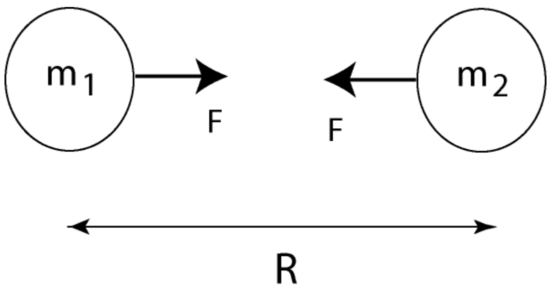
Friction $f = \mu W\cos\theta$

SLIDES when $W\sin\theta = f$

OR $\tan\theta = \mu$

LECTURE 6 PHY 2004

Gravity



Force

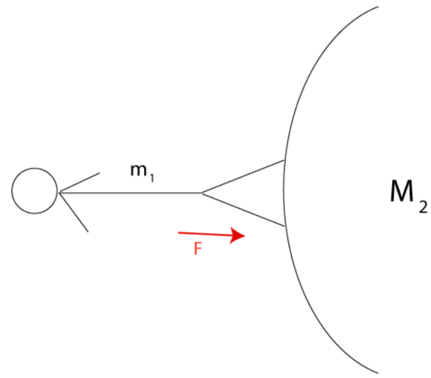
$$F = \frac{Gm_1m_2}{R^2}$$

G is universal constant

(same everywhere)

Weight

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



Thus

$$g = \frac{G m_2}{R^2}$$ **for mass on surface of planet M_2**

Problem 3.41

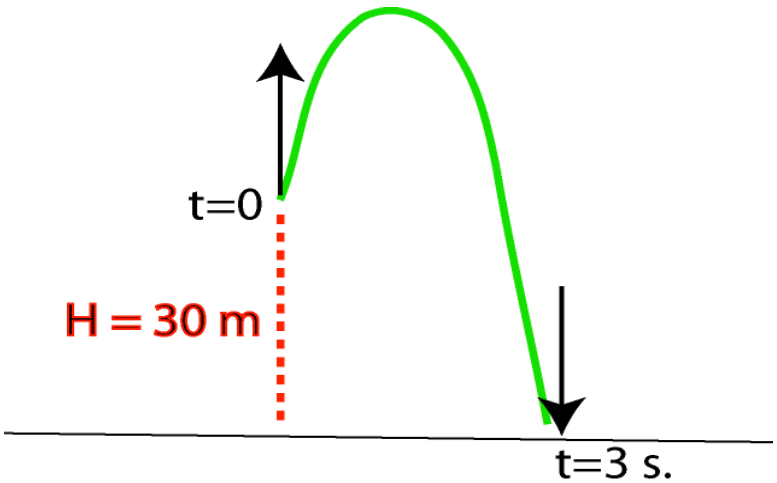
g(moon) =1.6m/s2

Weight on moon = 1.6(4) = 6.4 N

Weight on Earth = 9.8(4) 39.2 N

LECTURE 5 PHY 2004

Chap. 2 #43



$Y = V_i t + (1/2)at^2$ .... (1)

At end Y = -30 m (below origin)

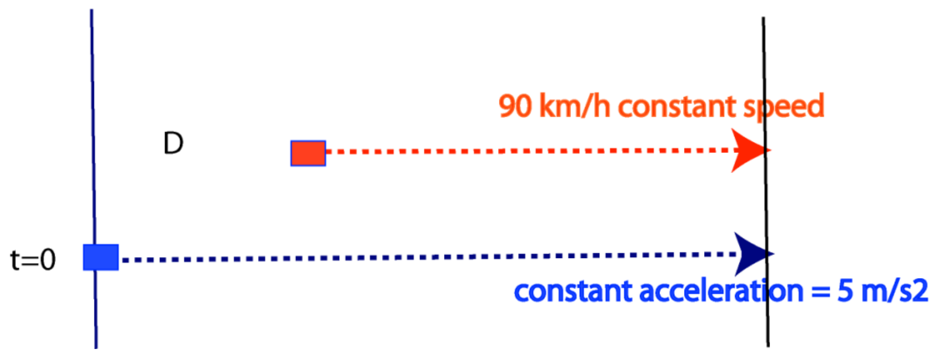
acceleration a = -g= -9.8m/s2

Put in Eq'n (1)

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

$V_i = (4.9)3 = 4.7$ m/s

Chap 2. # 35



Red speed constant = 90 km/h = 25 m/s

Blue does not start until 5 seconds after red passes, D=(5)(250)=125 m

Need to find t, then calculate distances

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

$X_{red} = 25\,t$

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

Use Eq'n (1)

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

$t^2 = 10t + 50$,

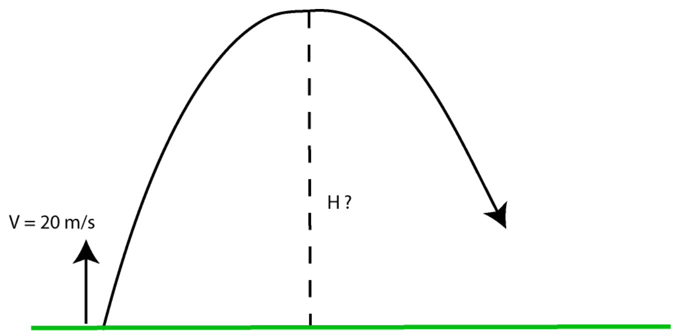
or $t=5 \pm \sqrt{(75)}$ (-ve sign non-physical)$=5 + 8.7 = 13.7$s

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

$X_{blue} = 466.5$ 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?

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

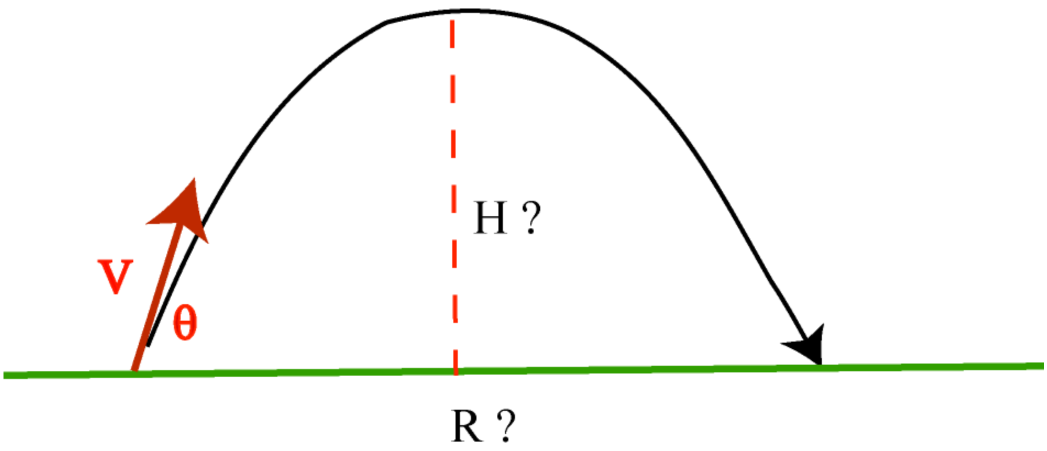
$a = -\,9.8\ m/s^2$ (gravity DOWN deceleration)

$V_F = 0$

$0 = 202 - 2(9.8)H$

$H = 400/19.6 = 20.4\ m$

Projectile Motion



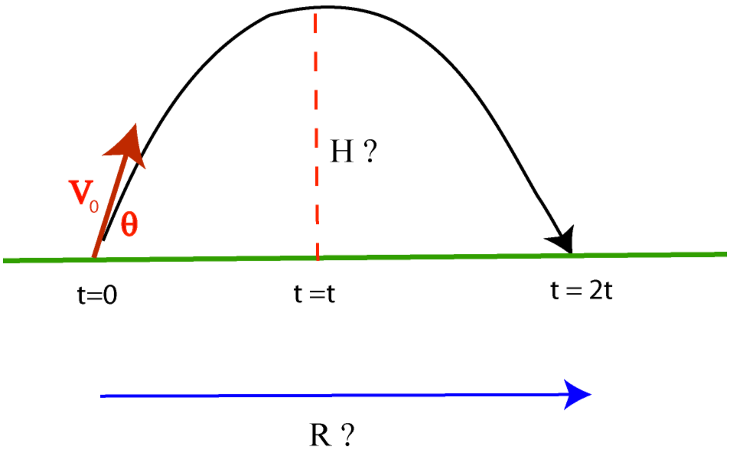
Initial velocity V at angle θ to horizontal

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_{avg} (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 $t = (V_0\sin\theta)/g$

$H = V_{avg}.t = (1/2)V_0 \sin\theta.(V_0\sin\theta/g)$ **No need to memorize this formulae, just remember simple red equations**

R= (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

Tel. 352-846-3137

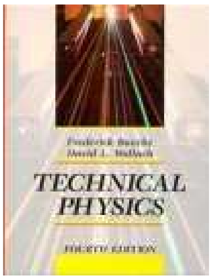
Class meets: M W F (Period 8) 3:00 -3:50 PM

NPB 1001

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

NPB 2235

Textbook:



Technical Physics

F. Bueche & D. Wallach

(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)

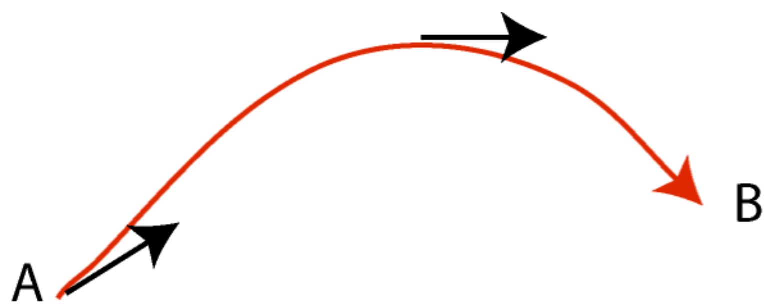
In class questions = bonus of 5 %

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

$a = (V_F - V_I)/t$ OR $V_F = V_I + at$

Uniform acceleration (typical in this class)

e.g. gravity, rockets

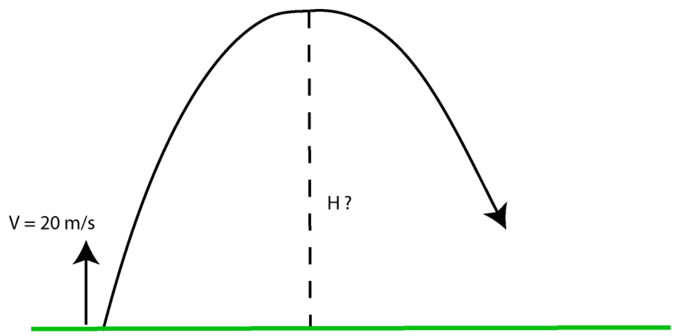
$X = V_{avg}\, t$ where V_{avg} is average velocity $V_{avg} = (V_I + V_F)/2$

THUS $X = (V_F^2 - V_I^2/2a)$ OR $V_F^2 = V_I^2 + 2aX$

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

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?

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$V_F = 0$

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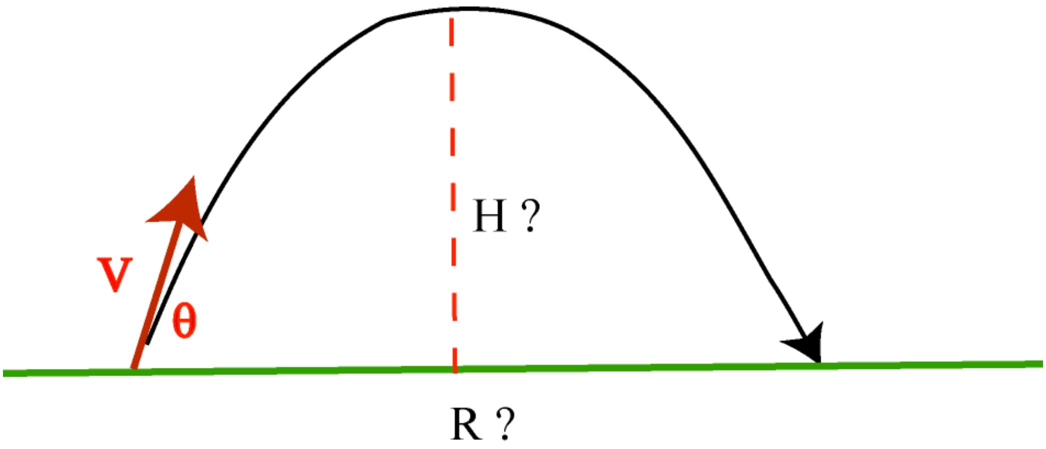
$H = 400/19.6 = 20.4 \text{ m}$

Projectile Motion



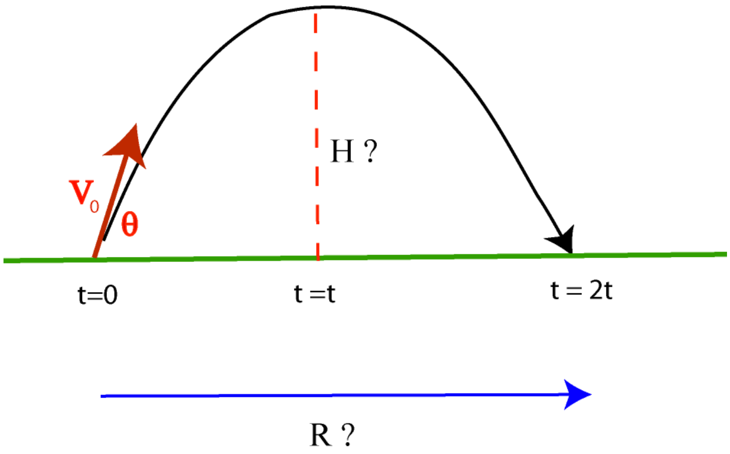
Initial velocity V at angle θ to horizontal

Calculate R

Calculate θ

LECTURE 4 PHY 2004

Continuing the above problem from lecture 3.



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R= (total time) $V_x = 2t\, V_0\cos\theta$