MOMENTUM

Collision

Impulse \[ I = F \cdot t \]

\[ F = ma = m(V_f - V_i)/t \]

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 $P=0$

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

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

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

Momentum initial = Momentum after

\[ M_1V_{1\text{Init}} + M_2V_{2\text{Init}} = M_1V_{1\text{after}} + M_2V_{2\text{after}} \]

No energy losses, therefore

\[ \frac{1}{2}M_1(V_{1\text{Init}})^2 + \frac{1}{2}M_2(V_{2\text{Init}})^2 = \frac{1}{2}M_1(V_{1\text{after}})^2 + \frac{1}{2}M_2(V_{2\text{after}})^2 \]

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
ANGULAR MEASUREMENTS

In time $t$

sweep out $\theta$

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

$\theta$ is in RADIANS

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

ANGULAR VELOCITY

$$\omega = \frac{\theta}{t} \quad \text{radians / sec.}$$
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 \( \Delta V \)

THEREFORE there is an acceleration toward the center

\[ a_c = \frac{V_T^2}{r} \]
PLANETS

Constant angular speed (approximately)

Centripetal acceleration = $V_T^2/r$

Provided by gravitational force

$F = GMm/r^2$

HENCE

$V_T = \sqrt{(GM/r)}$
No motion (OR constant motion i.e. no acceleration)

Vector sum of forces = 0

i.e. in figure to right $F_1 + F_2 = F_{\text{up}}$

In figure below,

Equilibrium requires

For horizontal direction;

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

For vertical direction;

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

Solve $T_1 = 150 \text{ N}$
Turning effect

Measure of turning or twisting (rotational or angular) motion

Torques must cancel

Torque

\[ \tau = d \times \text{perpendicular component of force to axis } d \]

\[ = dF \]

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

\[ W1 \times a1 + W2 \times a2 = 0 \]
ENERGY, WORK

Work

\[ W = F \times D. \]

\[ D = \text{distance in the same direction as the force} \]

Work by gravity

\[ F = mg \quad \text{If move against gravity do positive work} \]

\[ W = mgh \]

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

\[ \mu = \text{coefficient of friction} \quad f = \mu W \]

- 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 $\tan\theta = \mu$
Gravity

\[ F = \frac{G m_1 m_2}{R^2} \]

**G** is a 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

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

Weight on moon = 1.6(4) = 6.4 N

Weight on Earth = 9.8(4) 39.2 N
\[ Y = V_i t + \frac{1}{2} a t^2 \]  

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

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

Put in Eq’n (1) 

\[-30 = V_i \cdot 3 - \frac{1}{2}(9.8) \cdot 9\] 

\[ V_i = (4.9)3 = 4.7 \text{ m/s} \]
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: \( X_{\text{blue}} = X_{\text{red}} + 125 \) ..........................Eq’n (1)

\[
X_{\text{red}} = 25t \\
X_{\text{blue}} = \frac{1}{2}at^2 = \frac{1}{2}5t^2 = 2.5t^2
\]

Use Eq’n (1)

\[ 2.5t^2 = 25t + 125, \quad \text{or} \]
\[ t^2 = 10t + 50, \]

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

\( X_{\text{red}} = 25t =341.5 \text{ m} \)

\( X_{\text{blue}} = 466.5 \text{ m} \)
LECTURE 3  PHY 2004

Gravity  constant at Earth’s surface (always “down”)

![Diagram](image)

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)

\[ V_F = 0 \]

\[ 0 = 202 -2(9.8)H \]

\[ H = \frac{400}{19.6} = 20.4 \text{ m} \]
Projectile Motion

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

Calculate $R$

Calculate $\theta$
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 \( y = H \)

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

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

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

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

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 %
MOTION

Speed (scalar)  distance per unit time  \(\text{meters/sec}\)

Velocity (vector)  speed + direction

\[\text{Average velocity} = \text{displacement vector AB/time}\]
Acceleration (vector)

Rate of change of velocity

\[ a = \frac{(V_F - V_I)}{t} \quad \text{OR} \quad V_F = V_I + at \]

Uniform acceleration (typical in this class)

e.g. gravity, rockets

\[ X = V_{avg} \, t \quad \text{where} \quad V_{avg} \quad \text{is average velocity} \quad V_{avg} = \frac{(V_I + V_F)}{2} \]

THUS \[ X = \frac{(V_F^2 - V_I^2)}{2a} \quad \text{OR} \quad V_F^2 = V_I^2 + 2aX \]

ALSO \[ X = V_{avg} \, t \quad \text{OR} \quad X = V_I t + \frac{1}{2}at^2 \]
Gravity constant at Earth’s surface (always “down”)

![Diagram](image)

**Typical problem**

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\[ H = V_{avg\cdot t} = \frac{1}{2} V_0 \sin\theta \cdot \frac{V_0 \sin\theta}{g} \]

No need to memorize this formulae, just remember simple \textcolor{red}{red} equations

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