GENERAL PHYSICS I: PHYS 10

Schedule - Fall 2007
(lecture schedule is approximate)

Week	Day	Date	Lecture	Chapter	Topic	Lab / Tutorial
8	M	22	19	Chapter 7	Impulse and momentum	No lab or tutorial
	Tue	23	MID-TERM TEST, Ch 1-5, Tuesday, October 23, 7-9 pm			
	W	24	20	Chapter 7	Impulse and momentum	
	F	26	21	Chapter 8, sections 1-3 only	Rotational kinematics	
9	M	29	22			Experiment 3: Forces in Equilibrium
	W	31	23	Chapter 9 sections 1 - 3, 6	Rotational dynamics	
	F	Nov 2	24			
10	M	5	25	Chapter 10 exclude 10.7 and 10.8	Simple harmonic motion, sections 10.5 and 10.6, for self study only	Tutorial and Test 3 ~~(chapters 7, 8)~~ Chapters 6, 7
	W	7	26			
	F	9	27	Chapter 11 exclude 11.11	Fluids	

Week of October 29

Experiment 3: Forces in Equilibrium

PHYS 1020 Web Page

Instructors	Required Materials	Schedule	Policies/Evaluation	Suggested Problems	Formula Sheet

Answers to Even-Numbered Problems

Answers for tutorial test problems

Answers for midterm test

Mastering Physics Assignment #3
Due Friday, October 26 at 11 pm

Information on "Mastering Physics"

→ Marks files

Midterm Marks

Average: 13.6/20

Papers without responses were marked by hand

ID	Mark	3	5	2	3	2	4	2	4	3	1	1	4	2	2	3	5	4	1	5	4	1	1	1	2	4	2	4	1	1	1	5	1	4	2	3	1	4	3	5	1
	16																																								
	13																					1	1	1	2	4	2	4	2	1		1	2	4	2	5	1	4	3	2	3
	13																					1	1	1	2	4	3	4	1	1	1	5	5	4	3	5	2	4	3	3	3
	11																					3	1	3	2	4	4	4	1	1	1	1	1	1	3	5	1	4	3	4	5
	14	5	5	2	3	2	4	2	4	3	2	1	4	2	1	2	5	4	1	3	5																				
	17	3	5	3	3	2	4	2	2	3	1	1	4	5	2	3	5	4	1	5	4																				
	7																					5	1	1	2	4	4	1	2	1	3	5	3	3	1	1	1	5	5	4	5
	10	4	5	4	3	2	2	2	4	3	4	1	4	3	3	2	3	4	1	4	3																				

Mastering Physics Assignment 4

Is due Monday, November 12 at 11 pm

Covers material from chapters 6 and 7

There are 8 questions for practice and 6 for credit

Impulse and Momentum

Impulse = $F\Delta t$ = Δp = change in momentum

Momentum is constant if there is zero net applied force

Alternative statement of Newton's second law: $\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$

For a system of 2 or more colliding objects, momentum is conserved if there is zero net applied force:

$$\vec{p}_1 + \vec{p}_2 = \vec{p}_1{}' + \vec{p}_2{}'$$

Total momentum before = total momentum after

Clickers!

A canoe with two people aboard is coasting with an initial momentum of +110 kg.m/s. Then, one of the people (person 1) dives off the back of the canoe. During this time, the net average external force acting on the system of canoe and two people is zero.

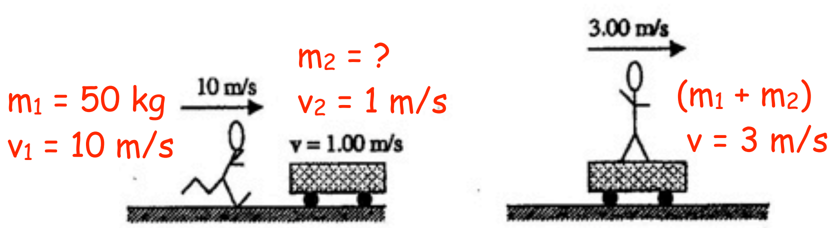
The table lists four possibilities for the final momentum of person 1 and the final momentum of the canoe with person 2, immediately after person 1 leaves the canoe. Only one possibility could be correct. Which is it?

	Person 1	Person 2 and canoe
A)	-60 kg.m/s	+170 kg.m/s
B)	-30 kg.m/s	+110 kg.m/s
C)	-40 kg.m/s	-70 kg.m/s
D)	+80 kg.m/s	-30 kg.m/s

Momentum is conserved!

Dec 2003 Final, Q25. A boy who weighs 50 kg runs at a speed of 10 m/s and jumps onto a cart, as shown. What is the mass of the cart?

(a) 175 kg (b) 350 kg (c) 117 kg (d) 88 kg (e) 163 kg

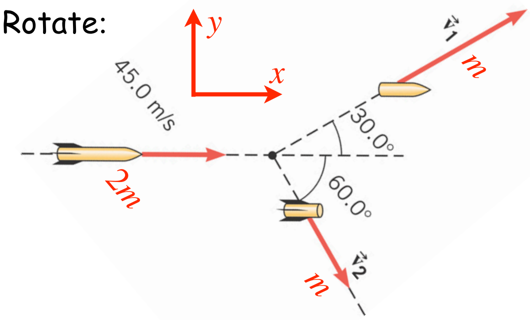


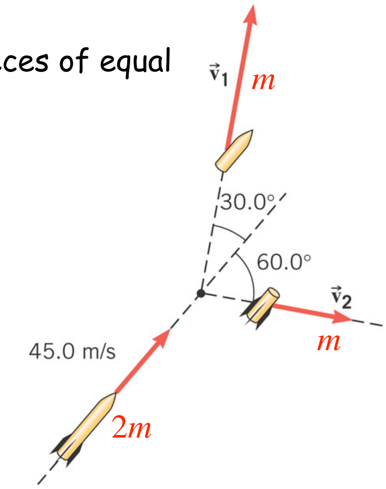
Conservation of momentum: $m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$

Solve for m_2: $m_2 = \frac{m_1(v_1 - v)}{v - v_2} = \frac{50(10-3)}{3-1} = 175\ \text{kg}$

7.19: A fireworks rocket breaks into two pieces of equal mass. Find the velocities of the pieces.

Rotate:





Momentum in x-direction: $2m \times 45 = mv_1 \cos 30° + mv_2 \cos 60°$ (1)

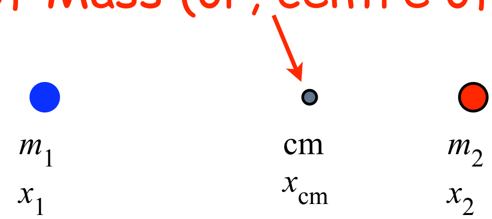
Momentum in y-direction: $0 = mv_1 \sin 30° - mv_2 \sin 60°$

$$\rightarrow v_2 = \frac{v_1 \sin 30°}{\sin 60°} = 0.5774 v_1 \quad (2)$$

Substitute into (1)

$$v_1 = \frac{90}{\cos 30° + 0.5774 \cos 60°} = 77.94 \text{ m/s} \qquad v_2 = 45.0 \text{ m/s}$$

Centre of Mass (or, centre of gravity)



The centre of mass of the two objects is defined as:

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

(The mean position weighted by the masses)

If the masses are moving, the centre of mass moves too:

$$\Delta x_{cm} = \frac{m_1 \Delta x_1 + m_2 \Delta x_2}{m_1 + m_2}$$

Motion of cm: $$\Delta x_{cm} = \frac{m_1 \Delta x_1 + m_2 \Delta x_2}{m_1 + m_2}$$

The speed of the centre of mass is:

$$v_{cm} = \frac{\Delta x_{cm}}{\Delta t} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2} = \frac{p_{tot}}{m_1 + m_2} \qquad (p_{tot} = p_1 + p_2)$$

Or, $p_{tot} = (m_1 + m_2) v_{cm}$

If zero net force acts on the masses, the total momentum is constant and the speed of the centre of mass is constant also, **even after a collision**.

In two or three dimensions:

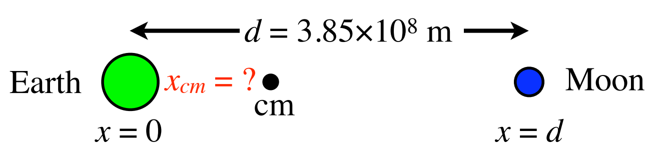
$$\vec{v}_{cm} = \frac{m_1 \vec{v}_1 + m_2 \vec{v}_2}{m_1 + m_2} = \text{ velocity of centre of mass}$$

$$\vec{p}_{tot} = (m_1 + m_2) \vec{v}_{cm}$$

7.41: The earth and the moon are separated by a centre-to-centre distance of 3.85×10^8 m. If:

$M_{earth} = 5.98 \times 10^{24}$ kg, $M_{moon} = 7.35 \times 10^{22}$ kg,

how far does the centre of mass lie from the centre of the earth?



Measuring distances from the centre of the earth:

$$x_{cm} = \frac{M_{earth} x_{earth} + M_{moon} x_{moon}}{M_{earth} + M_{moon}} = \frac{M_{earth} \times 0 + M_{moon} \times d}{M_{earth} + M_{moon}}$$

$$= \frac{7.35 \times 10^{22} \times 3.85 \times 10^8}{5.98 \times 10^{24} + 7.35 \times 10^{22}} = 4,675,000 \text{ m}$$

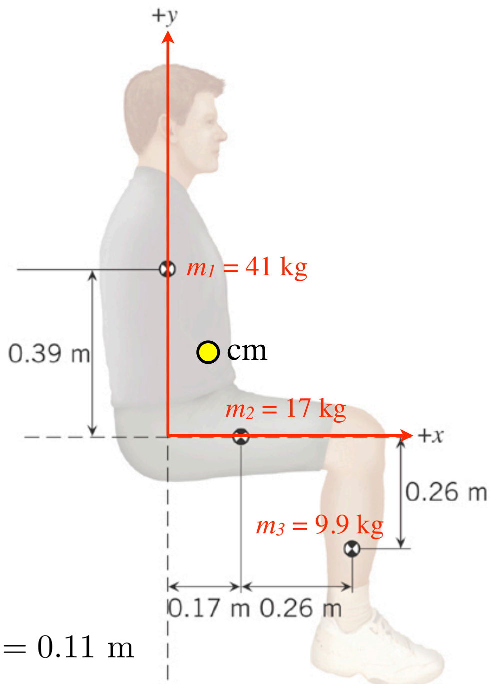
Note, the radius of the earth is 6,380 km, so the cm is inside the earth.

7.44/-: The figure shows the centres of mass of:

1) torso, neck and head, mass m_1 = 41 kg,
2) upper legs, mass m_2 = 17 kg,
3) lower legs and feet, mass m_3 = 9.9 kg.

Find the position of the centre of mass of the seated person.

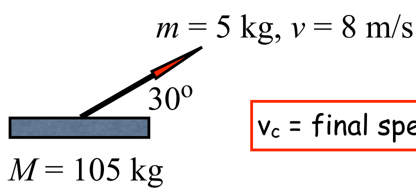
(NB minor appendages such as arms and hands have been left out for simplicity).



$$x_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$$
$$= \frac{41 \times 0 + 17 \times 0.17 + 9.9 \times 0.43}{41 + 17 + 9.9} = 0.11 \text{ m}$$

$$y_{cm} = \frac{m_1y_1 + m_2y_2 + m_3y_3}{m_1 + m_2 + m_3} = \frac{41 \times 0.39 + 17 \times 0 - 9.9 \times 0.26}{41 + 17 + 9.9} = 0.20 \text{ m}$$

7.54: A person stands in a stationary canoe and throws a 5 kg stone at 8 m/s at 30^0 above the horizontal. What is the recoil velocity of the canoe?



v_c = final speed of canoe

Conservation of momentum: canoe initially at rest, so momentum = 0
Or, centre of mass is at rest and remains so.

x: $$0 = mv\cos 30^\circ + Mv_c$$

$$v_c = \frac{-mv\cos 30^\circ}{M}$$
$$= \frac{-5 \times 8\cos 30^\circ}{105} = -0.33 \text{ m/s}$$

Summary

Momentum

$$\vec{p} = m\vec{v}$$

Impulse and Momentum – Newton's 2nd law in another form

$$\text{Impulse: } \vec{F}\Delta t = m\Delta\vec{v} = \Delta\vec{p}$$

Conservation of Momentum

$$\text{In the absence of applied forces: } \vec{p}_1 + \vec{p}_2 = \vec{p}_1{}' + \vec{p}_2{}'$$

Centre of Mass

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

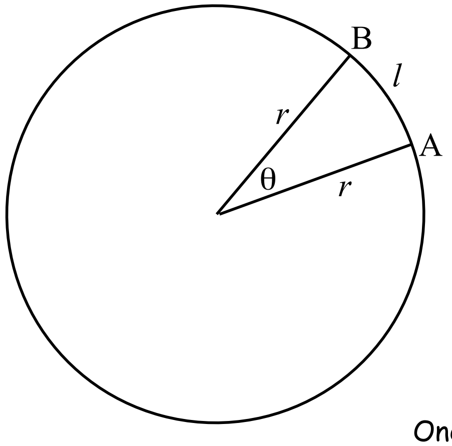
continues to move at constant velocity if no applied forces

Chapter 8, Rotational Kinematics

Sections 1 – 3 only

- Rotational motion and angular displacement
- Angular velocity and angular acceleration
- Equations of rotational kinematics

Angular Displacement



The length of the arc of the circle of radius r from A to B is:

$$l = r\theta$$

where θ is in radians.

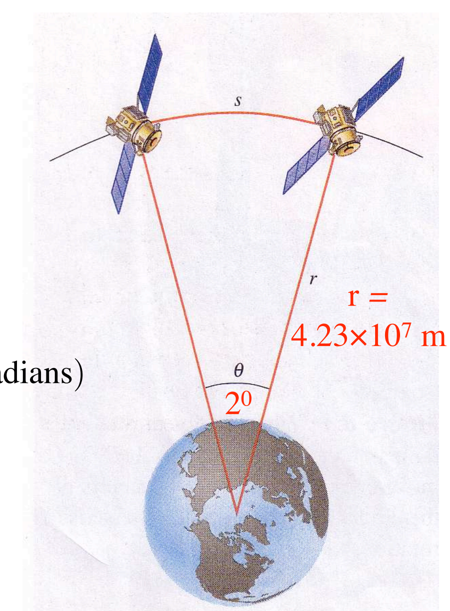
$$\theta\ (\text{radians}) = \frac{\text{arc length}}{\text{radius}} = \frac{l}{r}$$

One complete revolution corresponds to:

$$\theta = \frac{2\pi r}{r} = 2\pi \text{ radians} \qquad (\text{rad})$$

π radians = 180^0

Two geostationary satellites are at an altitude of 4.23×10^7 m. Their angular separation θ is 2^0.

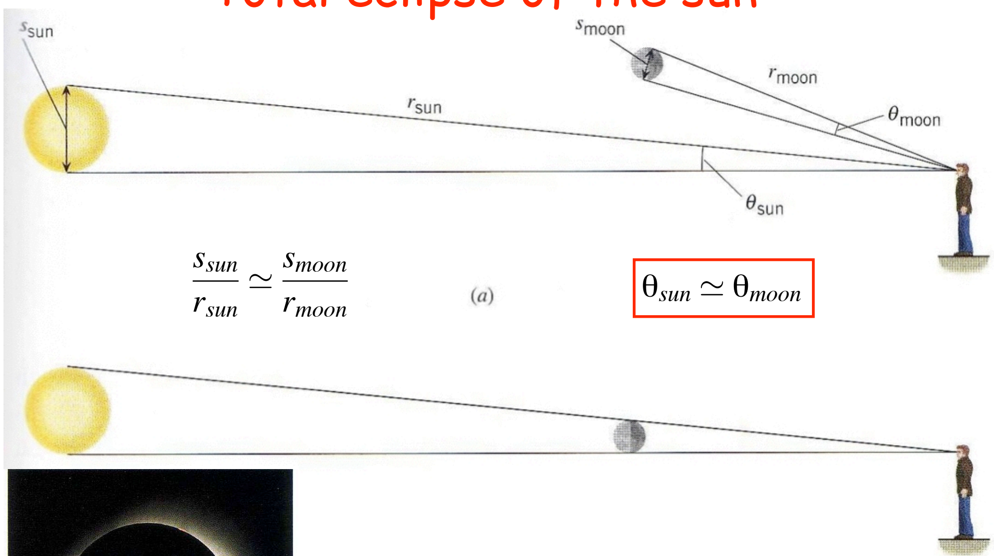


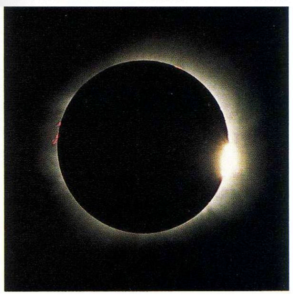
Find the arc length s.

s = r θ $= (4.23 \times 10^7 \text{ m}) \times (2\pi/180 \text{ radians})$

= 1.48×10^6 m

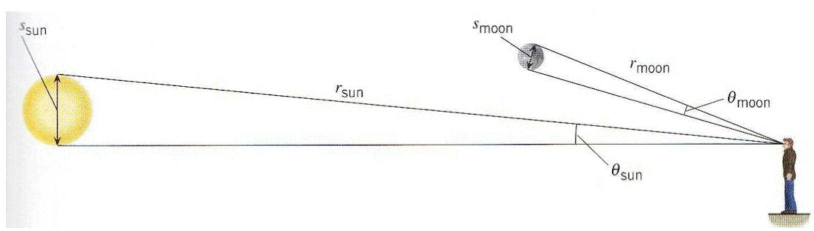
Total eclipse of the sun





The sun and moon have almost exactly the same angular size as seen from the earth even though the moon is much smaller than the sun.

8.68/14



Moon: diameter = 3.48×10^6 m,
distance from earth = 3.85×10^8 m

Sun: diameter = 1.39×10^9 m,
distance from earth = 1.50×10^{11} m

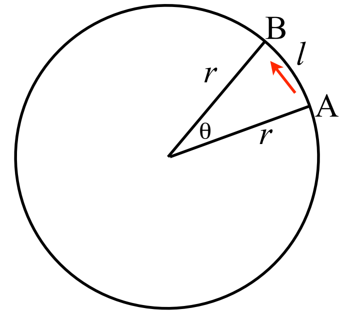
a) Angular size of moon = $(3.48 \times 10^6 \text{ m})/(3.85 \times 10^8 \text{ m}) = 0.00904$ rad

Angular size of sun = $(1.39 \times 10^9 \text{ m})/(1.50 \times 10^{11} \text{ m}) = 0.00927$ rad

b) The moon has slightly smaller angular size than the sun.

c) Apparent area of moon = $(0.00904/0.00927)^2 \times$ apparent area of sun
= 95.1% of apparent area of sun.

Angular velocity – motion around a circular path



Angular velocity is:

$$\bar{\omega} = \frac{\theta_B - \theta_A}{t_B - t_A} \text{ rad/s} \qquad \text{(average)}$$

$$\omega = \frac{\Delta\theta}{\Delta t} \text{ rad/s} \qquad \text{(instantaneous)}$$

The instantaneous angular velocity is measured over a vanishingly small time interval.

If the motion from A to B takes time t, then

$$v = \frac{l}{t} = \frac{r\theta}{t} = r\omega$$

That is, $v = r\omega$

Angular acceleration

Angular acceleration is the rate of change of angular velocity:

$$\text{Average angular acceleration } \bar{\alpha} = \frac{\omega - \omega_0}{t - t_0} = \frac{\Delta\omega}{\Delta t}$$

$$\text{Instantaneous angular acceleration } \alpha = \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t}$$

Equations for rotational motion

Analogous to the equations for linear motion.

$$\omega = \omega_0 + \alpha t$$

$$\theta = \frac{1}{2}(\omega_0 + \omega)t$$

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$v = v_0 + at$$

$$x = \frac{1}{2}(v_0 + v)t$$

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

$$v^2 = v_0^2 + 2ax$$