PHYS 1121, 1131, 1141.

Please don't leave spaces in rows of seats. The theatre will be nearly full.

Meanwhile, introduce yourself to your neighbours.

Text. Halliday, Resnick & Walker: *Fundamentals of Physics* (10^{th} or any recent edition)

You need to ***have access to a*** textbook (own, library, share; HR&W or a different one)

If you buy the on-line version, you don't need Wiley Plus (we shan't use it).

Lab manual and homework book: either buy from UNSW Bookshop or else download and print

All important information is on the UNSW Moodle site

You can ask physics and administrative questions there.

Regarding enrolments, see Student Central or (for this subject) the First Year Physics Office.

Lecturers: Joe Wolfe and Michael Burton. Course authority is Elizabeth Angstmann.

This lecture: we begin Mechanics (weeks 1-6).

Revise some high school kinematics. Converting units. Estimates.

Why Physics? Outline of physics in first year

PHYS 1121-1131-1141	**PHYS 1221-1231-1241**
(this session)	(next session)
Mechanics	Electricity and magnetism
Thermal	Physical optics
Waves & sound	Intro to quantum and solid state

PHYS 1121-1131 Mechanics (weeks 1-6)

Kinematics	describing motion	(including vectors & relative motion)
Dynamics:	forces	Newton's explanation of motion
	work and energy	~ Hamilton's explanation

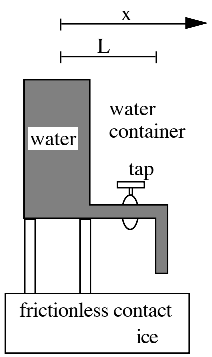
Centre of mass, momentum and collisions

Rotation

Gravity & planetary mechanics

Please don't leave spaces in rows of seats. The theatre will be nearly full. Meanwhile:

Basic question 1: Why are you studying physics? (Discuss with your neighbours.)



Challenge question 2. A tank (mass M, v= 0) on a frictionless surface contains water (mass m). L is distance from centre of mass of container to pipe. The pipe is small compared to the tank.

i) Open tap. When all the water has left, where is the tank (x = ?) and which way is it moving? (v = ?) Show a clear, quantitative derivation, (no fluid dynamics is required).

ii) *Explain* your answer in terms of forces on the tank.

Difficult, so a chocolate **prize** for the first clear answer.

(If the lecture goes too slowly for you, work on this problem.)

Fundamental question 3. Consider $\underline{\mathbf{F}} = m\underline{\mathbf{a}}$

i) Is this a law of physics? ii) Is it a definition of force? (If not, what is?)

iii) Is it a definition of inertial mass? (If not, what is?) *Can it be more than one of these?*

Estimation question 4. How many WIMPs in Phys 1A? Assume: all dark matter is WIMPs, $m_{WIMP} \sim 2 \times 10^{-27}$ kg; galactic density ~ 2×10^{-22} kg.m^{-3}, ~ 2000 students in Phys 1A.

Assumed mathematical knowledge:

- Solving quadratic equations
- Exponential and log
- Solving simultaneous equations
- Trigonometric functions and some identities
- Differentiation and integration
- Solving simple differential equations
- Plotting and reading graphs (Revise in labs)
- Appropriate use of significant figures (Revise in labs)

The following sections will be very rapid

Introduction to vector addition and subtraction

Vector components and resolving vectors

Need help? See MOOC Mechanics: Particles to Planets or Physclips

Assumed physics knowledge:

Officially none. However, we'll go ***quickly*** through parts of mechanics (eg projectiles)

Assessment:

See the Moodle site for the official document

Labs + fortnightly quizzes + end-of-session exam

How to do well in the exam? Practise by doing homework problems

We'll discuss more later

Learning outcomes

By the end of this course, you will understand the important principles of classical mechanics, thermal physics and waves, and you will be able

- to interpret problems in classical mechanics, thermal physics and waves
- to analyse and to quantify them, invoking **appropriate principles** and making **appropriate approximations**
- to **solve such problems** and to interpret the solutions

Lecture, problem solving workshop and homework components

- to plan an experimental investigation
- to make careful measurements
- to analyse experimental results, to test hypotheses and to discuss their implications

lab component

Learning resources for the lecture component of 1131/1121

- Lectures are here, see your timetable.
  Download lecture notes from Moodle (use mine, Prof Webb's or Wiley's).
  If you miss, recordings are on UNSW 'Echo 360'
- Problem Solving Workshops: Where you solve problems together
  from week 1 for 1121 & 1131, week 2 for 1141. (1141: study uncertainties in week 1)
- Teaching assistants. Personal assistance with problems. From week 2

Resources on line

- *Mechanics: Particles to Planets*. A UNSW on-line course by Joe Wolfe run by Coursera
- *Physclips.* More UNSW multimedia resources for introductory physics

We expect you to study ahead using on-line resources or the text book.

Revising kinematics

Questions for you to discuss with your neighbours

Question a: I drop a mass from height L, another from 2L. Does the second ball take

less than twice as long to fall

twice as long

more than twice as long

Question b: Explain your answer qualitatively, without equations or values

Question c: (only after you've answered the above): How much longer does the second ball take to fall.

Question d: I have a string with masses at heights 0, L, 2L, 3L, 4L. I drop the string.

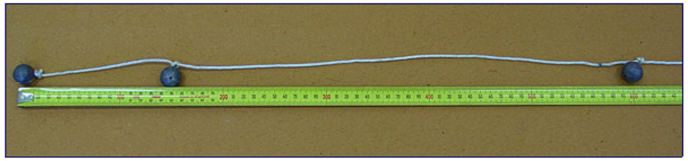
What will the soundtrack look like?

Question e: I have a string with masses at heights

0,	1^2L,	2^2L,	3^2L,	4^2L.	
0,	L,	4L,	9L,	16L.	
0	15 cm	60 cm	135 cm	240 cm	where L = 0.15 m

I drop the string. What will the soundtrack look like?

Mechanics > Projectiles > 2.2 An experiment with falling bodies



n	0	1	2	3	4
y_0	0	15 cm	60 cm	135 cm	240 cm
y_0 =	0^2 L	1^2 L	2^2 L	3^2 L	4^2 L

where L = 0.15 m

Remember $s = ut + ½at^2$

Question e: How do I space the weights so as to get equal times?

For y direction $(y - y_0) = v_{0y}t + ½a_yt^2$

$y = y_0 + v_{0y}t + ½a_yt^2$ *Important equation: we'll need it for projectiles*

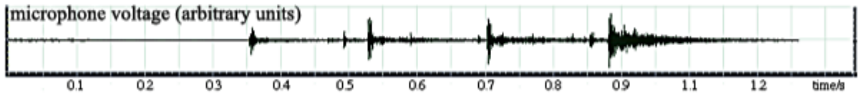
$y_0 = n^2L$. When it lands, $y = 0$. $v_{0y} = 0$. $a_y = -g$ (negative because y is up)

Substitute: $0 = n^2L - ½gt_n^2$

$n^2L = ½gt_n^2$

$$t_n = \sqrt{\frac{2L}{g}}\,n \quad \text{or} \quad t_n = nT \text{ where } T = \sqrt{\frac{2L}{g}}$$

We could plot t vs n and get g



Rearrange: $g = 2L(n/t)^2 = 2L/T^2$

where we define $T = t/n = t_1/1,\ t_2/2,\ t_3/3,\ t_4/4$ = time between landings

$g = 2L/T^2$ so do a rough experiment

Constant acceleration in y direction:

$$y = y_0 + v_{y0}t + \tfrac{1}{2}a_y t^2.$$

$$y = y_0 + \tfrac{1}{2}a_y t^2.$$

Drop from y_0 at $t = 0$. Floor at $y = 0$.

$$0 = y_0 + \tfrac{1}{2}a_y t^2.$$

$$y_0 = -\tfrac{1}{2}a_y t^2.$$

n	0	1	2	3	4
y_0	0	15	60	135	240 cm
	$= 0^2$ L	1^2 L	2^2 L	3^2 L	4^2 L

where L = 0.15 m

$$Ln^2 = -\tfrac{1}{2}a_y t^2$$

rearrange → $t^2 = -\dfrac{2L}{a_y}n^2$

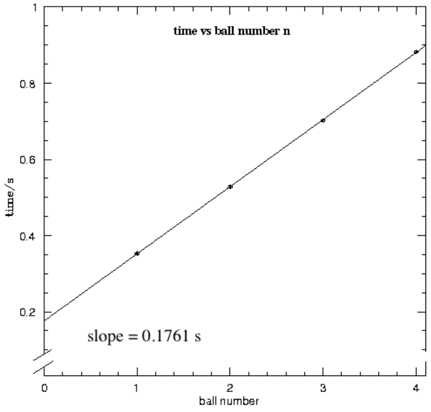
square root → $t = \sqrt{\dfrac{2L}{-a_y}}\,n.$

$$\text{slope} = \sqrt{\frac{2L}{-a_y}}$$

$$a_y = -\frac{2L}{(\text{slope})^2}$$

$$\cong -9.8 \text{ m.s}^{-2}.$$

Physclips version:



Conversion problem: Estimate the density of the galaxy, ρ_{galaxy}. Definition: $\rho = \dfrac{\text{mass}}{\text{volume}}$

Give your answer in kg.m^{-3} and in m_{proton}.m^{-3}

The answer depends on shape and where you draw the boundary but:

1.9 x 10^{11} M_s is located within 25 kpc of the centre. (Ruben, (1993) *PNAS*, **90**, 4814).

M_s means M_{sun} = 1.99 x 10^{30} kg kiloparsec = kpc = 3.1 × 10^{19} metres

m_p = 1.67 × 10^{-27} kg.

How to convert units: ***multiply by 1***

e.g. 1 inch = 25.4 mm (definition, exact)

so 1 = $\dfrac{25.4 \text{ mm}}{1 \text{ inch}}$

*so 12 inches = 12 inches * 1*

*= 12 inches ** $\dfrac{25.4 \text{ mm}}{1 \text{ inch}}$

= 300 mm (not 304.8 mm!)

significant figures in first lab exercise!

Conversion problem: What is the density of the galaxy, ρ_{galaxy}? Definition: $\rho = \dfrac{\text{mass}}{\text{volume}}$

Give your answer in kg.m^{-3} and in m_{proton}.m^{-3}

The answer depends on shape and where you draw the boundary but:

1.9 x 10^{11} M_s is located within 25 kpc of the centre. (Ruben, (1993) *PNAS*, **90**, 4814).

M_s means M_{sun} = 1.99 x 10^{30} kg kiloparsec = kpc = 3.1 × 10^{19} metres

m_p = 1.67 × 10^{-27} kg.

average density of a sphere with radius 25 kpc (rather less than the disc).

Conversion using the 'multiply by 1' technique, e.g. $M_{sun}/1.99 \times 10^{30}$ kg = 1

$$\text{density } \rho = \frac{mass}{volume} = \frac{3nM_s}{4\pi r^3} \sim \frac{nM_s}{4r^3} \sim \frac{(2\times10^{11}\text{suns})(2\times10^{30}\text{kg/sun})}{4\big((25\text{ kpc})(3\times10^{19}\text{ m/kpc})\big)^3}$$

~ 2 10^{-22} kg.m^{-3}

~ 10^5 proton masses/m^3. *Value depends on geometry and scale.*

Now we can answer: How many WIMPs in Phys 1A