PHYS*1A03 Introductory Physics

Fall 2015

http://avenue.mcmaster.ca/

A Quick Note on Lecture Notes

Hey Guys (*in the non-gender specific sense*),

I have tried to colour-code these slides for you; hopefully you'll find this useful!

- Light-Blue: Clicker Quizzes
- Light-Green: Class Activities/Discussions
- Ugly-Yellow: Additional/Important Slides (may not have been shown in class)

PHYS 1A03

Section C03:

Monday evening lectures 7-9 pm, in HSC 1A1

- Lecturer: Mike Massa

  massamv@mcmaster.ca

  Office: ABB 326A

Course Materials

Textbook (Recommended): ***Physics for the Life Sciences, 2nd edition*** by Zinke-Allmang and co-authors is an ideal companion to the material presented.

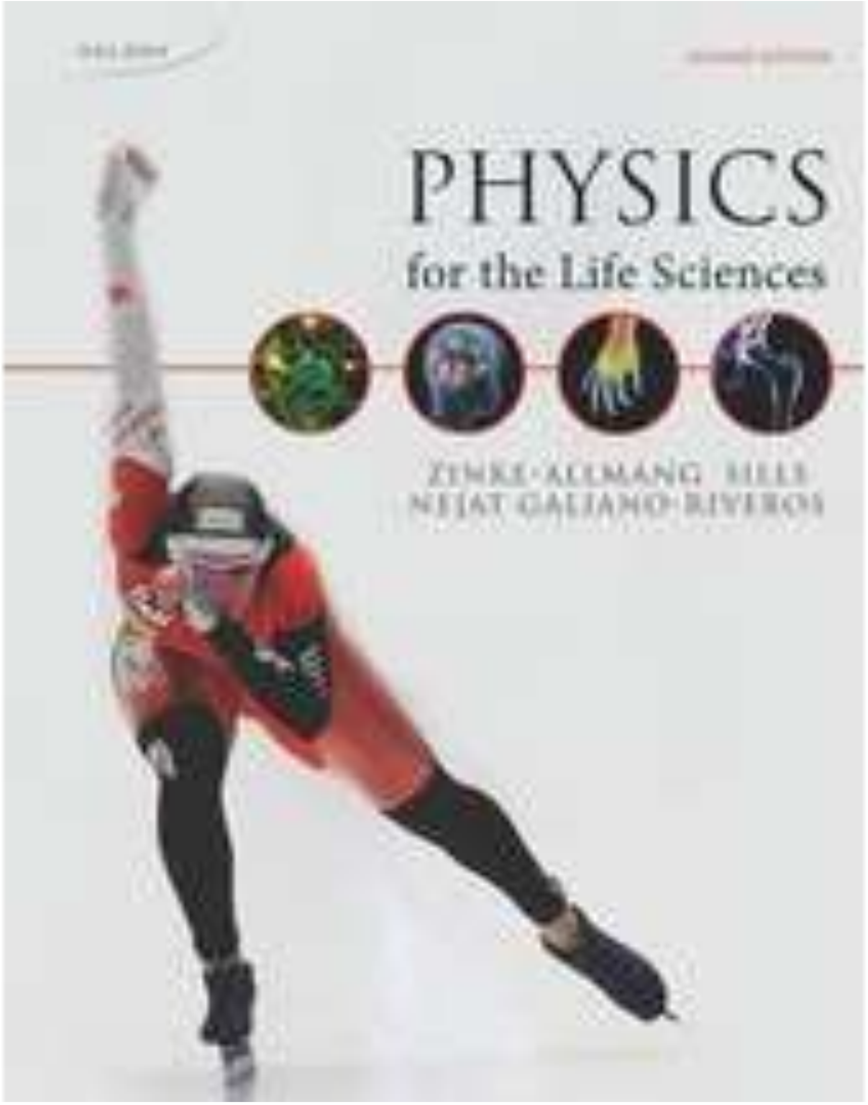
i>clickers (Required): i>clickers will be used in every class and are an integral part of the course.

Lab manual (Required): PHYS 1A03 Laboratory course manual available from the bookstore.

Lab notebook (Required): Black hard cover bound Physics Laboratory Notebooks available from the bookstore.

Calculator (Required): Only the McMaster Standard Calculator will be permitted during tests and examinations

Course Textbook



"Physics for the Life Sciences, 2nd Edition" by Zinke-Allmang

Available in the bookstore

Avenue to Learn

- Avenue is your main portal into the course material
  - Calendar of events
  - News items
  - Course outline – you must read this in carefully, the outline represents the contract between you and me
  - Online modules
  - Extra resources

- It is your responsibility to check Avenue regularly

Topics

- Broken up into 4 Themes, with sub-modules (see AtL)

  - Introduction and core concepts
    - Units, conversion, precision, estimation
  - Mechanics
    - Kinematics, forces, energy and momentum
  - Waves
    - Wave motion, superposition, sound, light
  - Fluids
    - Fluids, pressure, surface tension, flow, turbulence

Course Format

- **On-line modules** (11 in total) will provide an introduction to the course material
- **Lectures** (2 hrs per week) will serve to reinforce your understanding of the material
- **Labs** (5 in total: 4 typical labs + 1 home experiment)
- **Homework** will be assigned throughout the term – this may include on-line assignments & quizzes
- **Midterm tests**
  - Friday, October 9, 2015, 7-9 pm
  - Tuesday, November 10, 2015, 7-9 pm
- **Final Exam**
  - see McMaster Examination Timetable

Assessment in the Course

	Option 1	Option 2	Option 3
Class activities (i-clicker questions)	5%	5%	5%
Homework	5%	5%	5%
Labs	20%	20%	20%
Midterm 1	20%	15%	20%
Midterm 2	15%	20%	20%
Final Exam	35%	35%	30%

Labs

- 5 labs during the semester
    - 4 in the lab room
        - Kinematics in 1D
        - Forces
        - Conservation of energy
        - Waves, superposition and reflections
    - 1 home experiment on fluids
- Lab room is BSB B115, there are 18 sections, check your section carefully

Labs

- Labs start Monday September 28 (see AtL for schedule)
- Lab sections alternate week by week:
  - L01-L09:
    - Lab#1 week of 05.10.2015
    - Lab#2 week of 19.10.2015
    - Lab#3 week of 02.11.2015
    - Lab#4 week of 16.11.2015
  - L10-L18:
    - Lab#1 week of 28.09.2015
    - Lab#2 week of 26.10.2015
    - Lab#3 week of 09.11.2015
    - Lab#4 week of 23.11.2015
- Lab#5 will be assigned when we start topic on Fluids

LON-CAPA

- "Learning Online Network with Computer Assisted Personalized Approach"
- You log in and receive personalized questions (numbers are different)

https://loncapa.physics.mcmaster.ca

- On a nearly weekly basis questions will be assigned for practice **[these are NOT for marks]**
- **HOWEVER!** In class, we will have you solve one of your homework problems
  - Don't forget to bring yourself some paper!!

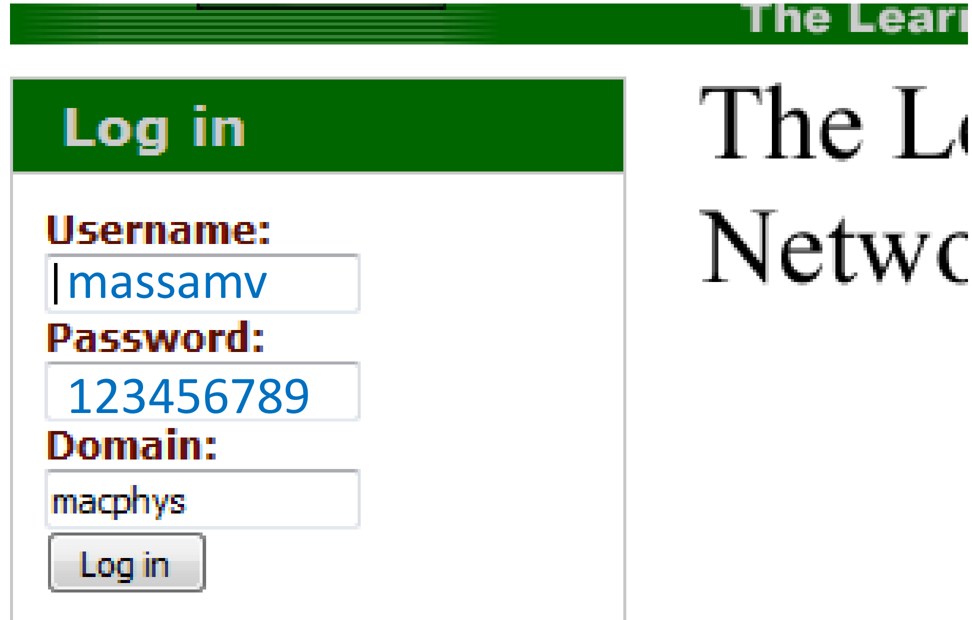
LON-CAPA

https://loncapa.physics.mcmaster.ca

Login:

Username is MacID

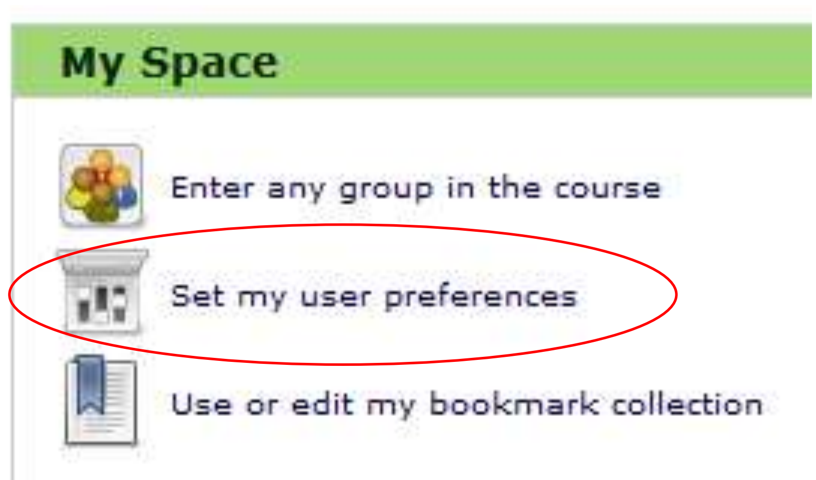
Password is Student #



Change your password!!

Click on “Main Menu”

then find this:



i-Clicker

- We will pose questions in class on a regular basis
  - Multiple choice
  - You click, we get instant feedback!
  - Participation is a crucial part of this course

General in-class questions

strictly participation

In-class Quizzes (based on modules)

additional marks for correct answers

- All questions count towards your total grade for class activities (5%)
- **Must have your iClicker by next class!!**

i-Clicker Registration

- i>clicker Web Registration
- Have questions about clicker registration? Contact us at support@iclicker.com or 866-209-5698.
- Thank you for using i>clicker! Please complete the form below. Your professor will then be able to give you credit for using your i>clicker in class.

First Name

Mike

Last Name

Massa

Student ID

massamv

Clicker ID

NOYB123

Getting Help

- Physics Drop-in Center
  - Basement of Thode Library, B108
  - Open Mon-Fri, 2-8 pm
  - Starting Monday, Sept 21 – Friday, Dec 4
  - Access to assistance from grad-student Tas!

C03: In-class Quizzes (Q) & Homeworks (h)

September

M	T	W	Th	F
	8	9	10	11
14	15	16	17	18
21 Q	22	23	24	25
28 Q	29	30		

October

M	T	W	Th	F
			1	2
5 Qh	6	7	8	9
12	13	14	15	16
19 Qh	20	21	22	23
26 Qh	27	28	29	30

November

M	T	W	Th	F
2 Qh	3	4	5	6
9 Qh	10	11	12	13
16 Qh	17	18	19	20
23 Qh	24	25	26	27
30 Qh				

December

M	T	W	Th	F
	1	2	3	4
7 Qh	8			

Academic Integrity

- ***If it feels like cheating, it probably is!***

- It is your responsibility to understand what constitutes academic dishonesty.

- For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3, located at

  http://www.mcmaster.ca/academicintegrity/

Physics?

- The goal of physics is to understand the way the world works
  - It's the study of the fundamental laws of nature

- Why study physics?
  - Physics is at the intersection of many disciplines (biophysics, medical physics, geophysics, etc.), ties these disciplines together, and bridges them to mathematics.

Physics and other areas of Science

- Chemistry – deals with interactions between atoms and molecules
- Medicine – diagnostic equipment and practices
  - Ultrasound & CT scans image using sound/electromagnetic waves
  - MRI & PET imaging use magnetic properties of atoms and exotic particles (positrons)
- Cell biology
  - Membrane structure and function
- Architecture
  - Structural stability, acoustics, heating, lighting…

The Chain Fountain

https://www.youtube.com/watch?v=_dQJBBklpQQ

Image taken from: http://phys.org/news/2014-01-chain-fountain-problem-solving-partnership-video.html

Books or Braun?

- Can we answer the ages-old question:

Who is stronger, man or book?

Can you beat a phone book in a tug-of-war?

Images taken from:
http://sciphile.org/lessons/phone-book-friction

http://www.france5.fr/emissions/on-n-est-pas-que-des-cobayes/experiences/experience-1-defi-suspendre-une-voiture-avec-deux-annuair-0

How does Physics work?

- Our understanding of the way the world works comes through observation, measurement and modeling
- **Observation** is essential for understanding a phenomenon
  - In physics, observations should be quantitative
- **Measurements** are observations with a numerical value (i.e. a "quantity", rather than a "quality")
  - Quantitative observations can tell us about the consistency and the extent of a phenomenon, how factors affect its behaviour
- **Models** are created to capture the essential features of a phenomenon
  - they offer a concise, often approximate, representation (analogy) for something that is difficult to describe directly

Models in physics

PANIC!!

- What can we say about how people panic in, say, a crowded classroom that's on fire?
- What kind of observations might we make of people leaving a room?

Simulating dynamical features of escape panic

Dirk Helbing*†, Illés Farkas‡ & Tamás Vicsek*‡

* Collegium Bu
H-1014 Budape
† Institute for E
D-01062 Dresd
‡ Department o
H-1117 Budapest, Hungary

$$\boxed{m_i \frac{d\mathbf{v}_i}{dt} = m_i \frac{v_i^0(t)\mathbf{e}_i^0(t) - \mathbf{v}_i(t)}{\tau_i} + \sum_{j(\neq i)} \mathbf{f}_{ij} + \sum_W \mathbf{f}_{iW}}$$

Problem solving

- Lots of people say “physics is hard”.
- It can evoke feelings similar to filling in your forms for university registration
  - You don’t know if you’re doing it correctly, and you’re worried that a single mistake will invalidate the whole process!

1. By far, the biggest mistake people make is giving up before you even get started

2. A second pitfall is thinking that physics is formulaic
   - If you’ve done a problem throwing a ball from a window, then you’ve done them all, and they all solve the same way

Problem solving

1. By far, the biggest mistake people make is giving up before you even get started
   - There are always things that can be done to start a problem
   - Write down what you know, and what you are asked to find
   - Draw a picture of what's going on in the problem

1. A second pitfall is thinking that physics is formulaic
   - Physics is not about memorizing formulas and jamming numbers into them

The real skills that we would like you to develop are:

- Assess what is going on in a problem
- Decide what's relevant
- Know what tools would be needed to solve the problem
- Be able to break the problem down into small steps, and approach the problem systematically

Problem solving

To repeat

- Physics is NOT about memorizing a lot of complicated equations
  - If you take this approach, you will do poorly

- Physics is about understanding a very small number of simple natural laws and learning to apply them to a wide variety of problems
  - We will encounter perhaps 10 important rules/ideas over the course

Physics 1A03

- Introductory course in physics
  - We have discussed how the course works
  - This is a brand new course, redesigned from the ground up with a different focus:
- **This course is not:**
  - a weeder course
  - a gate keeper to other programs
- **This course is:**
  - designed to give you an appreciation for physics
  - designed to teach you how to *model* the real world
  - designed with faculty input from other programs
  - designed keeping in mind different backgrounds

Theme 1
Introductory Material

Module T1M1:

The Predictable Universe

T1M1 – Learning Objectives

- Identify the approach taken by physicists to understanding complex phenomena.
- Recognize that measurements are really comparisons with a standard ***unit*** of measure, and that different standard units can be related to each other.
- Distinguish between the specific units of a measured quantity, and the more general statement of the ***dimensions*** of the quantity.
- Recognize that the dimensions of a quantity are helpful at predicting the relationships that govern a system.
- Understand the idea of ***proportionality*** to describe the specific way in which quantities are related.

Quantities

Base quantities

1. Length	metre (m)
2. Mass	kilogram (kg)
3. Time	second (s)
4. Electric current	Ampere (A)
5. Temperature	Kelvin (K)
6. Amount of substance	mole (mol)
7. Luminous intensity	candela (cd)

Making Quantitative Measurements

In order to make quantitative observations, we need to make measurements

Suppose are interested in learning about the height distribution of physics students?

- Our measurement of height
  - The quantity has both a numerical value (*magnitude*), as well as a **unit**
- It is important to have both a method of making measurements, and a system of units which allows us to
  - Measure accurately, consistently
  - Communicate with the scientific community
- There are many different units for a quantity
  - Need to be able to convert between different units
  - Good to have a standard system of units
  - We use SI units as our standard

Activity: Measuring a Student's Height

Results:

- We found that a student's height was 170 cm
- This could equivalently be expressed as
  - 17 TPs (toilet paper sheets)
  - 13 PTs (paper towel sheets)

- **Quick exercise:** Can you write up the conversion factors between all three units (TP $\leftrightarrow$ PT $\leftrightarrow$ cm)?

- **General feeling of the class:** "paper towels would be more useful for washroom breaks, but I probably shouldn't let people know I feel that way."

Base units and compound units

Quantity	SI units	Quantity	SI units
time	seconds (s)	acceleration	m/s^2
distance	metres (m)	force	Newtons ($N = kg\ m/s^2$)
mass	kilograms (kg)	energy	Joules ($J = kg\ m^2/s^2$)
temperature	Kelvin (K)	power	Watts ($W = J/s$)
area	metres squared (m^2)	pressure	Pascals ($Pa = N/m^2$)
volume	metres cubed (m^3)	density	kg/m^3
speed	metres/second (m/s)		

Definition of Base Units

Base quantities

1. Length (m)
2. Mass (kg)
3. Time (s)
4. Electric current (A)
5. Temperature (K)
6. Amount of substance (mol)
7. Luminous intensity (cd)

Veritasium

https://www.youtube.com/watch?v=ZMByI4s-D-Y

The kilogram

- Want to know what this is about?
- Check out: https://www.youtube.com/watch?v=ZMByI4s-D-Y

(don't think you have time to watch? Jump to 4:00 min to entice your curiosity)

Units & Unit Conversions

- Physical quantities are meaningless without units
- Unit conversions essentially take a quantity and multiply it by 1 (in a creative way)

$$2.54\ cm = 1\ in$$

$$\boxed{\frac{2.54\ cm}{1\ in} = 1} \qquad \boxed{1 = \frac{1\ in}{2.54\ cm}}$$

$$17\ in = 17\ \cancel{in} \times \frac{2.54\ cm}{1\ \cancel{in}}$$

$$= 43.2\ cm$$

$$10\ cm = 10\ \cancel{cm} \times \frac{1\ in}{2.54\ \cancel{cm}}$$

$$= 3.94\ in$$

Clicker Quiz

The blue whale is thought to be the largest animal ever to inhabit the Earth. The longest recorded blue whale had a length of 108 ft. If 1 ft = 30 cm, what is the length of this whale in meters?

A. 3.6 m
B. 32.4 m
C. 360 m
D. 3240 m

Answer

Conversion factors:

$$1\ ft = 30\ \ cm \qquad 1\ m = 100\ \ cm$$

$$1 = \frac{30\ cm}{1\ ft} \qquad 1 = \frac{1\ m}{100\ cm}$$

Calculate:

$$108\ ft = 108\ \cancel{ft} \times \frac{30\ \cancel{cm}}{1\ \cancel{ft}} \times \frac{1 m}{100\ \cancel{cm}} \boxed{= 32.4\ m}$$

Unit Conversion Practice

Here are some other common conversions to think about:

- Length – most common conversions are between
  - feet/metres, miles/km, inches/cm, and
  - Common SI units nm/μm/mm/cm/m/km
- Time – seconds/min/hour/day/year
- Mass – kilograms/pounds
- Speed –mph, km/h, m/s
- Area – cm^2 / m^2, plus Lengths^2 mentioned above

Clicker Quiz

- Volume conversion: How many cubic centimetres are there in one cubic metre?

A. 10

B. 100

C. 1000

D. 10^4

E. 10^6

$$\left(\frac{100\ cm}{1\ m}\right) \quad \left(\frac{100\ cm}{1\ m}\right) \quad \left(\frac{100\ cm}{1\ m}\right)$$

$$1\ m^3 = 1\ \cancel{m} \times 1\ \cancel{m} \times 1\ \cancel{m} \times \left(\frac{100\ cm}{1\ \cancel{m}}\right)^3$$

$$= (100\ cm)^3$$

$$= 10^6\ cm^3$$

The cost of Living

- **Being comfortable with unit conversions allows you to better process/interpret information:**
- What is a typical value for daily consumption (in Calories)?
  - **2000 Cal**
- Convert this to SI units of energy (Joules), given that there are 0.239 Calories in 1 kJ.

$$0.239\,Cal = 1\,kJ \longrightarrow 1 = \frac{1\,kJ}{0.239\,Cal}$$

$$2000\,Cal = 2000\,Cal \times \frac{1\,kJ}{0.239\,Cal} \times \frac{1000\;J}{1\,kJ} = 8.4\times10^{6}\;J$$

The cost of Living

- Does anybody know the SI units of Power (rate of energy consumption)?
  - **Watts [1 W = 1J/s]**
- Since we require 8.4 million Joules each day, on average we burn through energy at a rate of:

$$\frac{8.4\times10^{6}\ J}{24\ hrs}\times\frac{1\ hr}{3600\ s}=97\ J/s=97\ Watts\ !!$$

- Does this result sound at all familiar?

Dimensions

- "Dimension" refers to a basic ***type*** of quantity

  Example: Regardless of whether you measure your height in cm, inches or feet (or TP-rolls!), your height is a <u>length</u> quantity

We identify dimensions using square brackets

- Your height (length) $\rightarrow$ dimensions [L]
- Your age (time) $\rightarrow$ dimensions [T]
- How much of you there is
  - (mass) $\rightarrow$ dimensions [M]
  - (volume) $\rightarrow$ dimensions $[L^3]$
  - (as a food source - energy) $\rightarrow$ dimensions $[ML^2/T^2]$

Dimensions

- Dimensions of some common physical quantities

Quantity	**Symbol**	**Dimension**
Area	A	$[L^2]$
Volume	V	$[L^3]$
Speed	v	$[L/T]$
Acceleration	a	$[L/T^2]$
Force	F	$[ML/T^2]$
Pressure (F/A)	p	$[M/LT^2]$
Density (M/V)	ρ	$[M/L^3]$
Energy	E	$[ML^2/T^2]$
Power (E/t)	P	$[ML^2/T^3]$

Clicker Quiz

Which of the following equations is *dimensionally correct*?

a. $t = \frac{x \times a}{v^2}$

b. $v = v_o + x \times t$

c. x$= x_o + a \times t^2$

d. $shart = fart + small\ poop$

Clicker Quiz

Which of the following equations is *dimensionally correct*?

a. $t = \frac{x \times a}{v^2}$ $$[T] = \frac{[L] \times [L/T^2]}{[L/T]^2}$$

b. $v = v_o + x \times t$ $$[L/T] = [L/T] + [L] \times [T]$$

c. x$= x_o + a \times t^2$ $$[L] = [L] + [L/T^2] \times [T^2]$$

d. $shart = fart + small\ poop$

Clicker Quiz

The Ideal Gas Law:

- Physicists often write the ideal gas law as

$$\boldsymbol{PV = Nk_BT}$$

where *N* is the number of particles. What are the dimensions of the constant $\boldsymbol{k_B}$?

A. $\left[\frac{ML^2}{T^2K}\right]$

C. $\left[\frac{FL}{K}\right]$

B. $\left[\frac{ML^2}{NT^2K}\right]$

D. $\left[\frac{ML}{KT}\right]$

(Here *K* indicates the dimension of temperature)

Clicker Quiz

The Ideal Gas Law:

- Physicists often write the ideal gas law as

$$\boldsymbol{PV = Nk_BT}$$

where *N* is the number of particles. What are the dimensions of the constant $\boldsymbol{k_B}$?

Answer: Let's rewrite the expression for $\boldsymbol{k_B}$:, and use our Table (slide 46):

$$k_B = \frac{PV}{NT} = \frac{\left[\frac{M}{LT^2}\right][L^3]}{[-][K]} = \left[\frac{ML^2}{T^2K}\right]$$

Module Dos and Don'ts

- Writing stuff down:
  - Build your own formula sheet
  - Consider writing down formulas, and even write down what each symbol is in the formula.
  - Ex: $v_f = v_i + a\Delta t$

    v_i initial velocity

    v_f final velocity

    a acceleration

    Δt time interval
  - You'll notice that there are often Checkpoints on slides immediately afterwards, which build your understanding of the formulas (so, write them down!)
  - Evaluate your comfort/understanding level after watching the module
  - **ENJOY!!!**

Closing Comments

- Watch the module T1M1 before next class!
- Next class we will discuss:
  - Units and unit conversion
  - Dimensional analysis
  - Proportionality
  - Vectors
    - If you have never worked with vectors, watch the additional **Vector Module** for an introduction
    - If you have vector experience, take a quick look through the **Vector Review Notes** posted