PURDUE UNIVERSITY DEPARTMENT OF PHYSICS

Physics 21900

General Physics II

Electricity, Magnetism and Optics

Fall 2015 Semester

Prof. Matthew Jones

Physics 21900 – General Physics II

- Physics Department home page:
  - http://www.physics.purdue.edu
- Course home page(s):
  - http://www.physics.purdue.edu/~mjones/phys21900_Fall2015
  - http://www.physics.purdue.edu/phys219
- Blackboard Learn:
  - http://mycourses.purdue.edu/
- Mastering Physics:
  - http://www.pearsonmylabandmastering.com/northamerica/
  - Course ID: **meier58602**
- Rooms:
  - Physics 112: Lecture theater
  - Physics 150: Lab
  - Physics 144: Undergraduate Office
  - Physics 11: Help center

EMERGENCY PREPAREDNESS – A MESSAGE FROM PURDUE

To report an emergency, call 911. To obtain updates regarding an ongoing emergency, sign up for Purdue Alert text messages, view www.purdue.edu/ea.

There are nearly 300 Emergency Telephones outdoors across campus and in parking garages that connect directly to the PUPD. If you feel threatened or need help, push the button and you will be connected immediately.

If we hear a fire alarm during class we will immediately suspend class, evacuate the building, and proceed outdoors. Do not use the elevator.

If we are notified during class of a Shelter in Place requirement for a tornado warning, we will suspend class and shelter in the basement.

If we are notified during class of a Shelter in Place requirement for a hazardous materials release, or a civil disturbance, including a shooting or other use of weapons, we will suspend class and shelter in the classroom, shutting the door and turning off the lights.

Please review the Emergency Preparedness website for additional information.
http://www.purdue.edu/ehps/emergency_preparedness/index.html

Physics 21900

Acknowledgments

The content and style of the lecture notes may draw heavily on the most excellent set of notes prepared by *Prof. Ron Reifenberger* who taught this course during the Spring 2015 semester.

Historical Perspective

- Aristotle was (perhaps) the first to think about the causes of natural phenomena, rather than just document them.
- So far, most of the physics you have studied was developed between 200-400 years ago.
- Quantitative description of nature with accurate predictions.
- Coincident with new developments in mathematics (*eg*. Calculus) that were needed to accurately describe dynamic physical systems.

Mathematical Description of Nature

- In this course, we will try very hard not to mention calculus.
- We will describe many specific examples of physical systems, but usually not try to provide the “most general” description.
- It will be very efficient to describe the properties of physical systems using algebraic equations, but this is just for convenience…

Mathematical Description of Nature

MAY we not infer from this experiment, that the attraction of electricity is ſubject to the ſame laws with that of gravitation, and is therefore according to the ſquares of the diſtances; ſince it is eaſily demonſtrated, that were the earth in the form of a ſhell, a body in the inſide of it would not be attracted to one ſide more than another?

(Joseph Priestly, 1767)

$$F \propto \frac{1}{r^2}$$

Quantitative Description of Nature

- We can work out equations that can describe measurements, in some cases with great accuracy.

$$F = k\frac{Q_1 Q_2}{r^2}$$

- If we had numbers for everything on the right, then we could calculate the thing on the left.
- To use this, we need to agree on a consistent system of units.

System of Units

QUANTITY AND DEFINITION	METRIC cgs	METRIC MKS	ENGLISH FPS
TIME	SECOND	SECOND	SECOND
LENGTH	CENTIMETER	METER	FOOT
MASS	GRAM	KILOGRAM	slug
VELOCITY $v = d/t$	$\frac{\text{centimeter}}{\text{second}}$	$\frac{\text{meter}}{\text{second}}$	$\frac{\text{foot}}{\text{second}}$
ACCELERATION $a = v/t$	$\frac{\text{centimeter}}{\text{second}^2}$	$\frac{\text{meter}}{\text{second}^2}$	$\frac{\text{foot}}{\text{second}^2}$
FORCE $F = ma$	$\frac{\text{gm}\cdot\text{cm}}{\text{sec}^2} \equiv$ dyne	$\frac{\text{kg}\cdot\text{meter}}{\text{sec}^2} \equiv$ newton	POUND
ENERGY (& WORK) $W = fd$	$\frac{\text{gm}\cdot\text{cm}^2}{\text{sec}^2} \equiv$ erg	$\frac{\text{kg}\cdot\text{meter}^2}{\text{sec}^2} \equiv$ joule	foot·pound
POWER $P = W/t$	$\frac{\text{erg}}{\text{sec}}$	$\frac{\text{joule}}{\text{sec}} \equiv$ watt	$\frac{\text{foot}\cdot\text{pound}}{\text{second}}$
MOMENTUM $p = mv$	$\frac{\text{gm}\cdot\text{cm}}{\text{sec}} =$ dyne·s	$\frac{\text{kg}\cdot\text{meter}}{\text{sec}} =$ N·s	$\frac{\text{slug}\cdot\text{foot}}{\text{sec}}$
TORQUE $G = F\tau$	dyne·cm	newton·meter	pound·foot
FREQUENCY	$\frac{1}{\text{sec}} =$ hertz	$\frac{1}{\text{sec}} =$ hertz	$\frac{1}{\text{sec}} =$ hertz

Sometimes we will measure energy in electron-Volts:

$$1\ \text{eV} = 1.602 \times 10^{-19}\ \text{Joules}$$

Math Skills

- We will make use of the following concepts:
  - Algebra
    - One equation in one unknown
    - Sine, cosine, tangent, exponentials
  - Basic geometry
    - Right triangles, Pythagoras' theorem
  - Scientific notation
    - Including SI prefixes (kilo, mega, micro, etc…)
  - Simple vector concepts
- If you are uncomfortable with any of these, please do something!

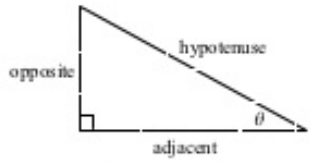
Math Skills

Trig Cheat Sheet

Definition of the Trig Functions

Right triangle definition

For this definition we assume that $0 < \theta < \frac{\pi}{2}$ or $0^\circ < \theta < 90^\circ$.



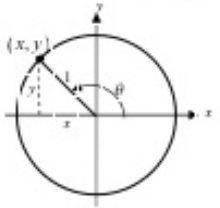
$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}} \qquad \csc\theta = \frac{\text{hypotenuse}}{\text{opposite}}$$

$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}} \qquad \sec\theta = \frac{\text{hypotenuse}}{\text{adjacent}}$$

$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}} \qquad \cot\theta = \frac{\text{adjacent}}{\text{opposite}}$$

Unit circle definition

For this definition θ is any angle.



$$\sin\theta = \frac{y}{1} = y \qquad \csc\theta = \frac{1}{y}$$

$$\cos\theta = \frac{x}{1} = x \qquad \sec\theta = \frac{1}{x}$$

$$\tan\theta = \frac{y}{x} \qquad \cot\theta = \frac{x}{y}$$

Facts and Properties

Domain

The domain is all the values of θ that can be plugged into the function.

$\sin\theta$, θ can be any angle

$\cos\theta$, θ can be any angle

$\tan\theta$, $\theta \neq \left(n+\frac{1}{2}\right)\pi$, $n = 0, \pm1, \pm2, \ldots$

$\csc\theta$, $\theta \neq n\pi$, $n = 0, \pm1, \pm2, \ldots$

$\sec\theta$, $\theta \neq \left(n+\frac{1}{2}\right)\pi$, $n = 0, \pm1, \pm2, \ldots$

$\cot\theta$, $\theta \neq n\pi$, $n = 0, \pm1, \pm2, \ldots$

Range

The range is all possible values to get out of the function.

$-1 \le \sin\theta \le 1$ $\quad \csc\theta \ge 1$ and $\csc\theta \le -1$

$-1 \le \cos\theta \le 1$ $\quad \sec\theta \ge 1$ and $\sec\theta \le -1$

$-\infty < \tan\theta < \infty$ $\quad -\infty < \cot\theta < \infty$

Period

The period of a function is the number, T, such that $f(\theta + T) = f(\theta)$. So, if ω is a fixed number and θ is any angle we have the following periods.

$$\sin(\omega\theta) \rightarrow T = \frac{2\pi}{\omega}$$

$$\cos(\omega\theta) \rightarrow T = \frac{2\pi}{\omega}$$

$$\tan(\omega\theta) \rightarrow T = \frac{\pi}{\omega}$$

$$\csc(\omega\theta) \rightarrow T = \frac{2\pi}{\omega}$$

$$\sec(\omega\theta) \rightarrow T = \frac{2\pi}{\omega}$$

$$\cot(\omega\theta) \rightarrow T = \frac{\pi}{\omega}$$

Formulas and Identities

Tangent and Cotangent Identities

$$\tan\theta = \frac{\sin\theta}{\cos\theta} \qquad \cot\theta = \frac{\cos\theta}{\sin\theta}$$

Reciprocal Identities

$$\csc\theta = \frac{1}{\sin\theta} \qquad \sin\theta = \frac{1}{\csc\theta}$$

$$\sec\theta = \frac{1}{\cos\theta} \qquad \cos\theta = \frac{1}{\sec\theta}$$

$$\cot\theta = \frac{1}{\tan\theta} \qquad \tan\theta = \frac{1}{\cot\theta}$$

Pythagorean Identities

$$\sin^2\theta + \cos^2\theta = 1$$

$$\tan^2\theta + 1 = \sec^2\theta$$

$$1 + \cot^2\theta = \csc^2\theta$$

Even/Odd Formulas

$$\sin(-\theta) = -\sin\theta \qquad \csc(-\theta) = -\csc\theta$$

$$\cos(-\theta) = \cos\theta \qquad \sec(-\theta) = \sec\theta$$

$$\tan(-\theta) = -\tan\theta \qquad \cot(-\theta) = -\cot\theta$$

Periodic Formulas

If n is an integer.

$$\sin(\theta + 2\pi n) = \sin\theta \qquad \csc(\theta + 2\pi n) = \csc\theta$$

$$\cos(\theta + 2\pi n) = \cos\theta \qquad \sec(\theta + 2\pi n) = \sec\theta$$

$$\tan(\theta + \pi n) = \tan\theta \qquad \cot(\theta + \pi n) = \cot\theta$$

Double Angle Formulas

$$\sin(2\theta) = 2\sin\theta\cos\theta$$

$$\cos(2\theta) = \cos^2\theta - \sin^2\theta$$

$$= 2\cos^2\theta - 1$$

$$= 1 - 2\sin^2\theta$$

$$\tan(2\theta) = \frac{2\tan\theta}{1 - \tan^2\theta}$$

Degrees to Radians Formulas

If x is an angle in degrees and t is an angle in radians then

$$\frac{\pi}{180} = \frac{t}{x} \quad \Rightarrow \quad t = \frac{\pi x}{180} \quad \text{and} \quad x = \frac{180t}{\pi}$$

Half Angle Formulas

$$\sin^2\theta = \frac{1}{2}(1 - \cos(2\theta))$$

$$\cos^2\theta = \frac{1}{2}(1 + \cos(2\theta))$$

$$\tan^2\theta = \frac{1 - \cos(2\theta)}{1 + \cos(2\theta)}$$

Sum and Difference Formulas

$$\sin(\alpha \pm \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$$

$$\cos(\alpha \pm \beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta$$

$$\tan(\alpha \pm \beta) = \frac{\tan\alpha \pm \tan\beta}{1 \mp \tan\alpha\tan\beta}$$

Product to Sum Formulas

$$\sin\alpha\sin\beta = \frac{1}{2}\left[\cos(\alpha - \beta) - \cos(\alpha + \beta)\right]$$

$$\cos\alpha\cos\beta = \frac{1}{2}\left[\cos(\alpha - \beta) + \cos(\alpha + \beta)\right]$$

$$\sin\alpha\cos\beta = \frac{1}{2}\left[\sin(\alpha + \beta) + \sin(\alpha - \beta)\right]$$

$$\cos\alpha\sin\beta = \frac{1}{2}\left[\sin(\alpha + \beta) - \sin(\alpha - \beta)\right]$$

Sum to Product Formulas

$$\sin\alpha + \sin\beta = 2\sin\left(\frac{\alpha + \beta}{2}\right)\cos\left(\frac{\alpha - \beta}{2}\right)$$

$$\sin\alpha - \sin\beta = 2\cos\left(\frac{\alpha + \beta}{2}\right)\sin\left(\frac{\alpha - \beta}{2}\right)$$

$$\cos\alpha + \cos\beta = 2\cos\left(\frac{\alpha + \beta}{2}\right)\cos\left(\frac{\alpha - \beta}{2}\right)$$

$$\cos\alpha - \cos\beta = -2\sin\left(\frac{\alpha + \beta}{2}\right)\sin\left(\frac{\alpha - \beta}{2}\right)$$

Cofunction Formulas

$$\sin\left(\frac{\pi}{2} - \theta\right) = \cos\theta \qquad \cos\left(\frac{\pi}{2} - \theta\right) = \sin\theta$$

$$\csc\left(\frac{\pi}{2} - \theta\right) = \sec\theta \qquad \sec\left(\frac{\pi}{2} - \theta\right) = \csc\theta$$

$$\tan\left(\frac{\pi}{2} - \theta\right) = \cot\theta \qquad \cot\left(\frac{\pi}{2} - \theta\right) = \tan\theta$$

Math Skills

Prefixes	Value	Standard form	Symbol
Tera	1 000 000 000 000	10^{12}	T
Giga	1 000 000 000	10^{9}	G
Mega	1 000 000	10^{6}	M
Kilo	1 000	10^{3}	k
deci	0.1	10^{-1}	d
centi	0.01	10^{-2}	c
milli	0.001	10^{-3}	m
micro	0.000 001	10^{-6}	μ
nano	0.000 000 001	10^{-9}	n
pico	0.000 000 000 001	10^{-12}	p

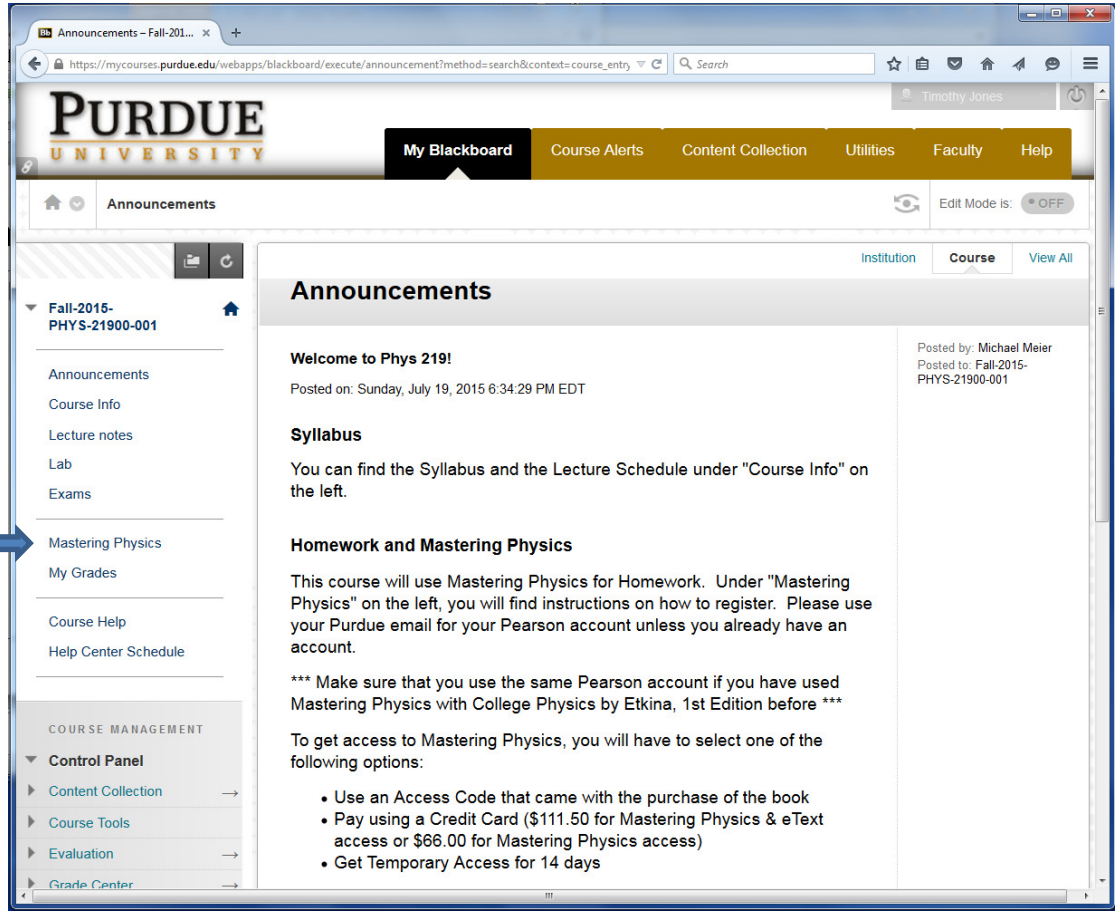
About the Course

- The syllabus is available from one of the web sites listed on the second slide.
  - Describes the grading scheme
  - Course schedule
  - Exam dates
- Assignments will be completed online using Pearson Publishing's MasteringPhysics®…
  - This is an improvement over free alternatives
  - Unfortunately you have to pay for it
  - But you probably already have if you took Physics 218.

Online Assignments

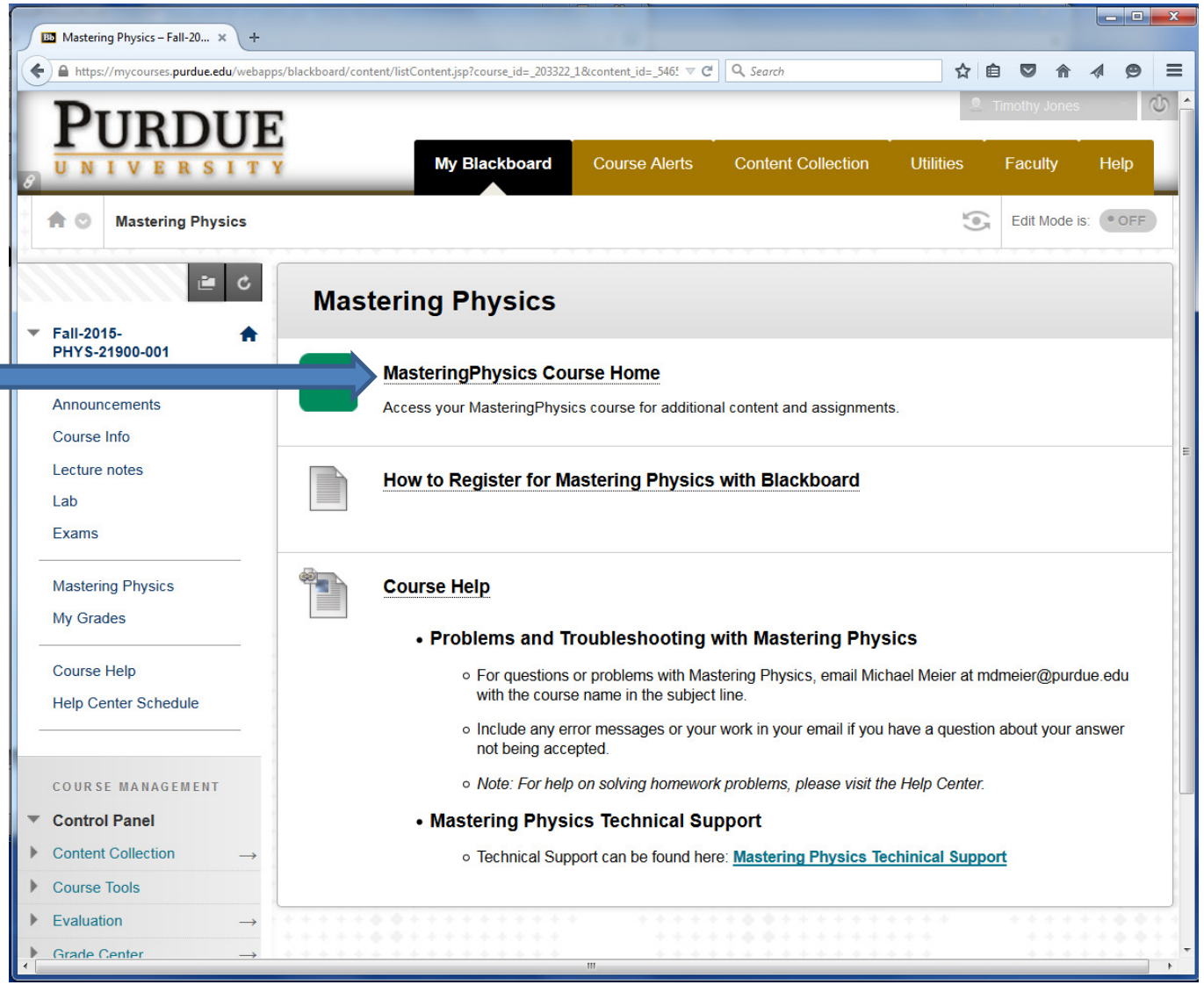
- Somehow get to the course page in Blackboard:

Click on this link



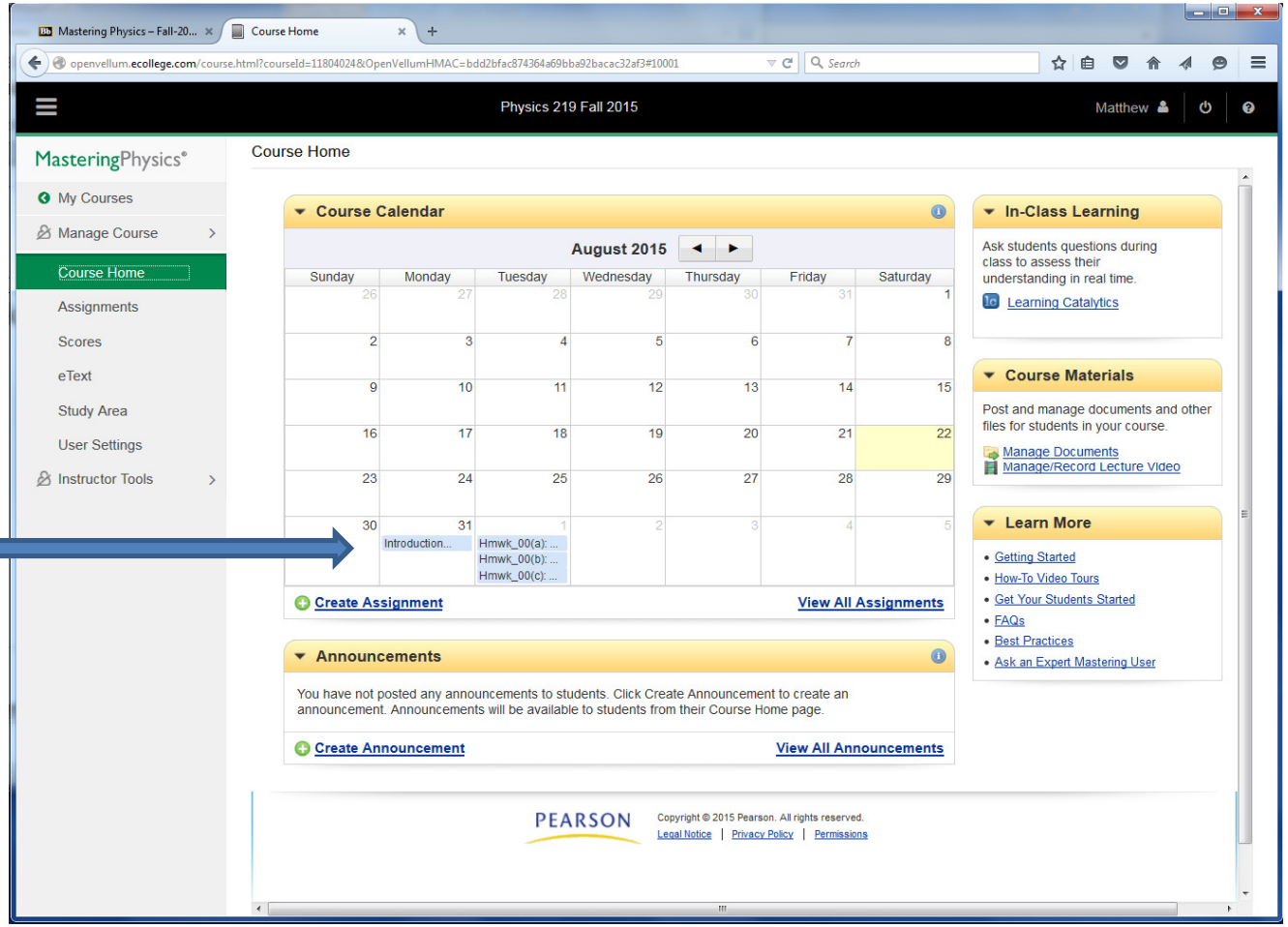
Online Assignments

Now click this link…



MasteringPhysics®

Assignments!

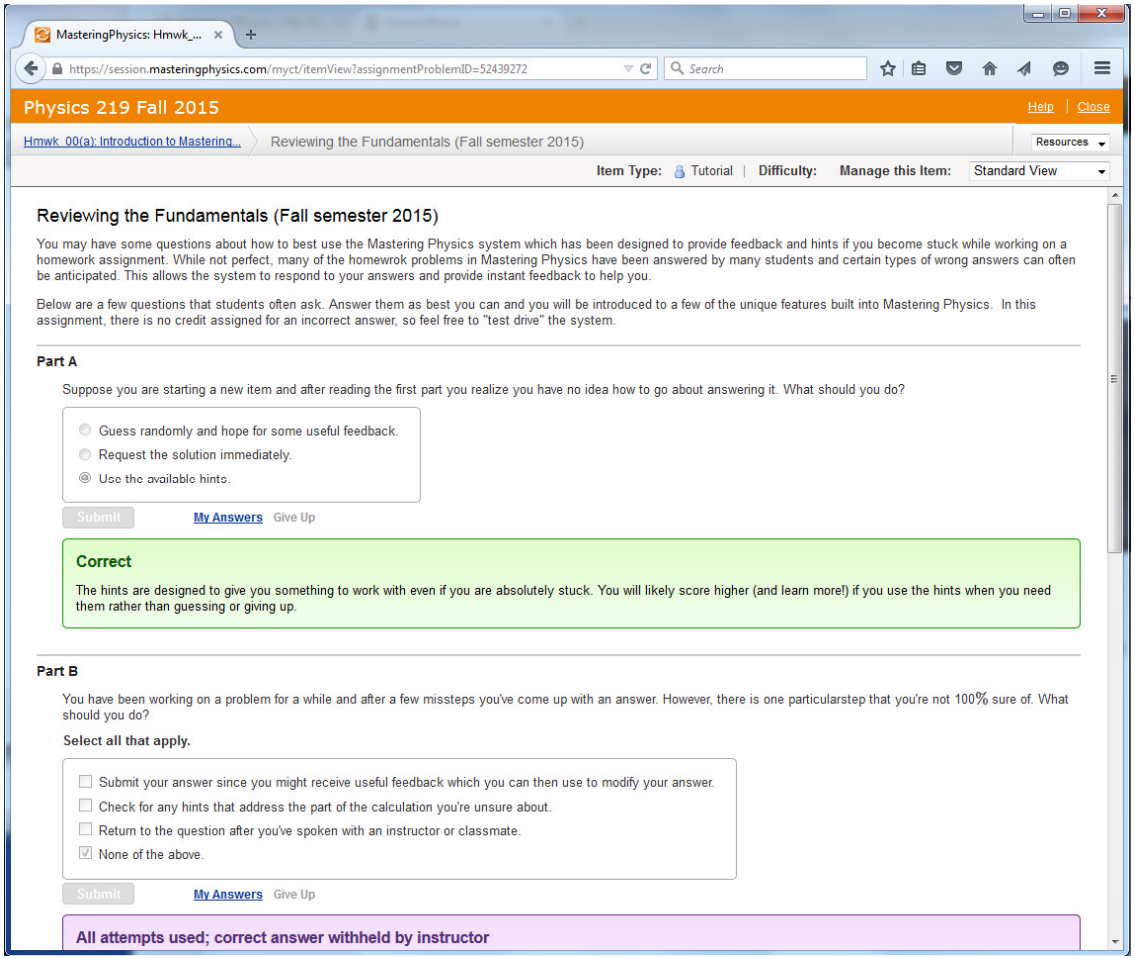


MasteringPhysics® Assignments

You need to look at the first “assignment”.

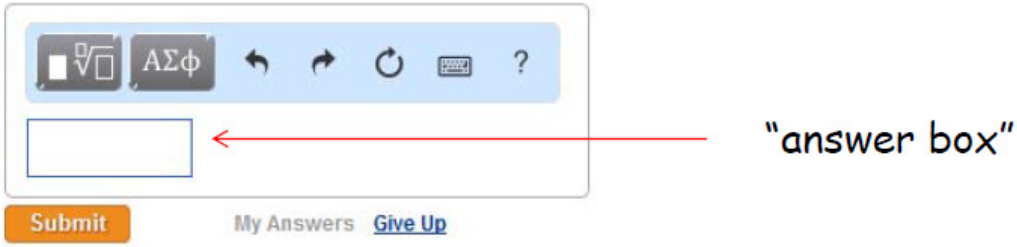
It is not for credit but it will walk you through many important aspects of the online homework system.

It’s not that hard, and you need to start somewhere.



Entering Numerical or Algebraic Answers

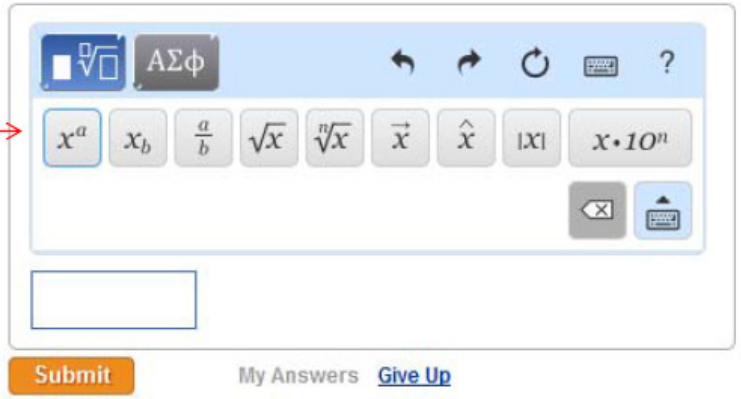
If the answer to a question requires a NUMERICAL or ALGEBRIC answer, then the box shown below will appear after a question is posed.



"answer box"

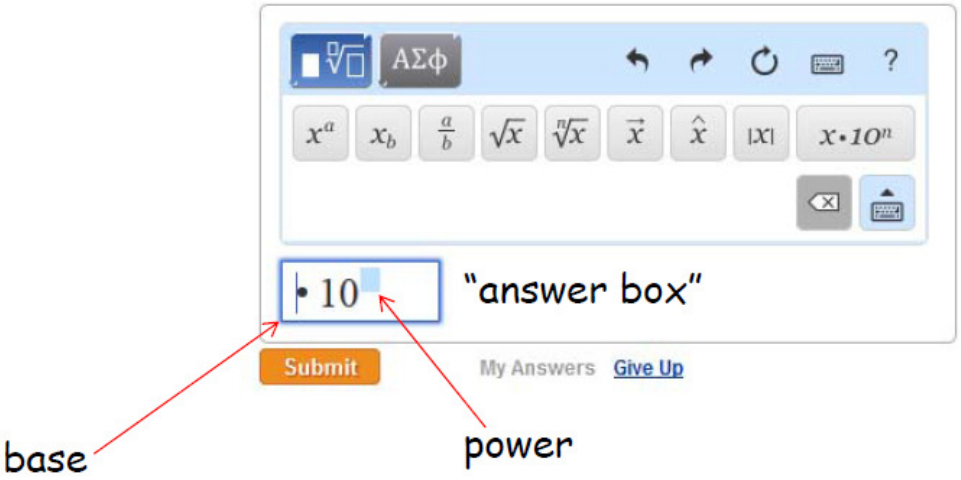
If you click the icon  , then another window will open that looks like:

By clicking on the grey-colored symbols, you can create an equation-like expression in the "answer box" to facilitate any numerical or algebraic answer that you care to enter.



Entering Numerical or Algebraic Answers

For instance, clicking on the $x \cdot 10^n$ icon, causes the "answer box" to look like this:



You can now enter numbers for the base and power into the "answer box" by positioning the mouse cursor at the end of either of the two red arrows and right clicking the mouse.

Entering Numerical or Algebraic Answers

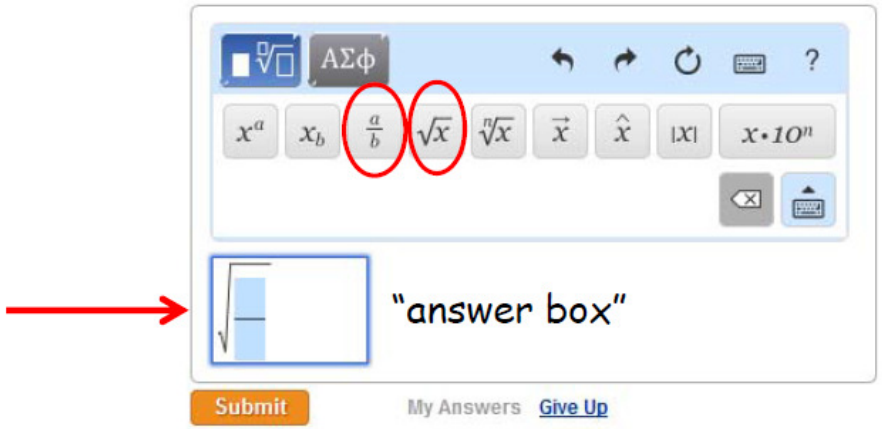
Be aware that Mastering Physics accepts algebraic answers. So, for instance, you can be asked a question like:

If $y=2x^2 + b$, what is x?

The correct answer would be $x = \sqrt{\frac{y-b}{2}}$

Note that Mastering Physics would also accept $x = \sqrt{\frac{-(b-y)}{2}}$

To enter this answer, you would first be required to select the square root symbol ($\sqrt{x}$) and then the fractional symbol (a/b) by clicking on the options provided in the grey boxes shown below. Then you would type y-b in the numerator blue box and 2 in the denominator blue box. You submit your answer by clicking on the "Submit" orange box.



More Information

- To register for course, go to

http://www.pearsonmylabandmastering.com

when asked, use the Course ID: **meier58602**

- To sign into the course to access homework assignments, quizzes, etc., go to

http://www.pearsonmylabandmastering.com/northamerica/

- For a step-by-step guide to get started, go to

http://www.pearsonmylabandmastering.com/northamerica/students/mm-support/index.html

- For a summary of the many features available in Mastering Physics, go to

http://www.pearsonmylabandmastering.com/northamerica/students/features/index.html

- For Questions and Answers about Mastering Physics, go to

http://www.pearsonmylabandmastering.com/northamerica/students/mm-support/top-questions/index.html

- For a Student User Guide, go to

http://help.pearsoncmg.com/mastering/student/ccng/index.htm