

Syllabus for AP Physics C: Mechanics

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Room 318

Text: Serway/Jewett: *Physics for Scientists and Engineers*

Course Description: AP Physics C Mechanics is a calculus based physics class equivalent to a first semester college Physics class. The course covers the following 6 topics: kinematics; Newton's laws of motion; work, energy, and power; systems of particles and linear momentum; circular motion and rotation; and oscillations and gravitation. This course is preparation for the American College Board AP Physics C Mechanics exam. Approximately 20% of this class will be lab work, and students are expected to keep a portfolio of their work.

Following the introduction of new material, homework problems are assigned. The students discuss the conceptual questions in class, and work out the exercises on the board. The students must clearly explain what they did to solve a problem and are always welcome to discuss the solution with their classmates as they work the problem. I try to interject as little as possible, but I do stop wrong solutions and ask the students to correct any wrong thinking. Prior to completing hands on labs, the students are given a list of the materials they may use along with the central question of the lab. As a class they discuss the validity of their own procedures and ultimately decide on the procedure for the lab.

Course Evaluation: According to district policy, grades will be broken down into Major and Minor Assessments for each quarter.

Major Assessments (60%)

Tests

Lab Reports

Minor Assessments (40%)

Homework Quizzes

Equation Quizzes

Other Lab Work

The overall yearly grade is a combination of 20% each quarter grade, and 10% midterm and final exam.

Tentative course units (subject to change)

Unit 1: Introduction and Review (Summer work)

Unit 2: 1D Motion

Unit 3: Vectors & Motion in Two and Three Dimensions

Unit 4: Forces and Motion

Unit 5: Energy, Work, and Power

Unit 6: Systems of Particles and Linear Momentum

Unit 7: Circular Motion and Rotation

Unit 8: Equilibrium and Gravitation

Unit 9: Oscillations

AP Physics Summer Assignment

Read all information carefully and complete all problems. You must show your work for the problems to receive credit. Work may be shown on a separate sheet of paper if necessary.

Greek Letters

In Physics, we use variables to denote a variety of unknowns and concepts. Many of these variables are letters of the Greek alphabet. If you are not familiar with these letters, you should become so. While there is no practice work for this section and while you do not have to outright memorize these letters at this point, you need to have this exposure so that when class starts and you see this on the board: μ you don't call it, "that funny-looking m-thing".

These variables have specific names and I will be using these names. You need to do this as well.

| Greek Letter | Name | Commonly used for |
|--------------|---------------------|--|
| | Alpha (lowercase) | Angular acceleration, radiation particle |
| | Beta (lowercase) | Radiation particle |
| | Delta (uppercase) | Showing a change in a quantity |
| | Epsilon (lowercase) | Permittivity |
| | Phi (lowercase) | Magnetic Flux, work function |
| | Gamma (lowercase) | Radioactivity, relativity |
| | Lambda (lowercase) | Wavelength |
| | Mu (lowercase) | coefficient of friction |
| | Pi (lowercase) | Mathematical constant |
| | Theta (lowercase) | Angle name |
| | Rho (lowercase) | Density, resistivity |
| | Sigma (uppercase) | Showing the sum of numbers |
| | Tau (lowercase) | Torque |
| | Omega (lowercase) | Angular velocity |
| | Xi (uppercase) | Electromotive force; induced voltage |

The Metric System

Everything in physics is measured in the metric system. The only time that you will see English units is when you convert them to metric units. The metric system is also called SI (from the French, "Système International"). In the SI system fundamental quantities are measured in meters, kilograms, and seconds.

Here are the metric prefixes that we will use throughout the year:

| Name of prefix | Numerical value | Abbreviation |
|----------------|-----------------|--------------|
| | 10^{-12} | p |
| | 10^{-9} | n |
| | 10^{-6} | μ |
| | 10^{-3} | m |
| | 10^{-2} | c |
| | 10^3 | k |
| | 10^6 | M |
| | 10^9 | G |

* Adapted from onwraevens.net

AP Physics **M** Summer Assignment

Read all information carefully and complete all problems. You must show your work for the problems to receive credit. Work may be shown on a separate sheet of paper if necessary.

Note that the symbol for micro- is the lowercase Greek letter mu. Its name is "mu" (pronounced "me-you") and not, "that funny-looking m-thing".

To help memorize some of these prefixes: micro- is the same prefix used in the word, "microscope" which is a tool used to view very small things. Mega- and micro- both start with the letter "m" and stand for, respectively, "million" and "millionth".

I. Measurements and Significant Figures

When using a measuring device, you **MUST** estimate between the smallest marks on the instrument. For example, if a ruler is marked off in increments of whole millimeters, you estimate the length of an object to the closest tenth of a millimeter.

Use the ruler below to measure the length of the arrow. Remember to estimate between the smallest marks.



The length of the arrow is _____ mm.

Precision is also important in labs and when solving problems. In Physics, the same thing is true—you can not round numbers at will. You must obey the rules for significant figures.

| | example | # of sig. figs. |
|---|------------------------------------|--|
| Non - zero numbers are significant. | 126 245 g | 6 |
| Zeros between non - zero numbers are significant. | 12 027 m | 5 |
| Zeros at the end of the number to the right of the decimal are significant. | 23.00 kg | 4 |
| Zeros in front of non zero numbers are not significant. | 0.0502 s | 3 |
| Zeros at the end of the number to the left of the decimal are not significant unless they were measured. Use scientific notation for clarity. | 1000 m 1.00 x 10 ³ m | unknown, could be 1 to 4 3, zeros would not be shown unless they were measured. |

When adding or subtracting numbers, the precision of the answer can be no greater than the precision of the least precise value.

$$\begin{array}{r}
 97.3 \\
 4.32 \\
 + 0.147 \\
 \hline
 101.767
 \end{array}$$

(least precise value, your answer will be rounded to the same decimal place as this value)

→ round to nearest 1/10th so final answer is 101.8

97.3 is only known to the nearest 1/10th, 4.32 to the nearest 1/100th, and 0.147 to the nearest 1/1000th. Therefore the final answer must be rounded to the nearest 1/10th.

AP Physics Summer Assignment

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When multiplying or dividing numbers, the final answer has the same number of significant figures as the measurement having the smallest number of significant figures.

$$\begin{array}{r} 9.81 \\ \times 0.0053 \\ \hline 0.051993 \end{array}$$

3 significant figures
2 significant figures
round to 2 significant figures \rightarrow 0.052

In laboratory work, values calculated from measurements cannot be more precise than the measurements themselves. For example, if we measure the sides of a cube to be 0.252 m, 0.253 m, and 0.251 m, when the volume is determined we use significant figure rules.

$$0.252 \times 0.253 \times 0.251 = 0.016002756 \text{ in a calculator.}$$

However, we can only keep three significant figures, so you would record 0.0160 m^3 .

Note that significant figures rules are a guideline to determine precision of calculations. The actual experimental conditions and procedures may result in precision that is worse than what significant figures rules allow. But the precision of calculations based on one-time measurements cannot be better than what the significant figures rules allow.

In Physics, we often use the slope of a best-fit line to average together the results of many measurements.

Problems:

- Two students are measuring the density of a block of wood. The measurements of the block are length = 0.240 m, width = 0.152 m and height = 0.205 m. The mass is measured to be 4.253 kilograms. Calculate the density to the correct number of significant digits. (Recall that density is mass divided by volume.) How could this experiment be improved using the slope of a graph? What would you graph?
- To determine the average velocity of a bowling ball, students measure the distance traveled as 15.00 meters, and the time as 10.35 seconds. Calculate the average velocity to the correct number of significant figures. (Recall that velocity is displacement divided by time.) Considering human reaction time, do you think significant figures rules give a valid estimation of the precision of the experiment? Explain. How could this experiment be improved using the slope of a graph? What would you graph?

Vectors

Please view the Force + vector powerpoint and work the 10 problems on the next page.

(google search - henrysciencedwd \rightarrow for powerpoint)

VECTOR ADDITION

- ⇒ Sketch a diagram for each problem, then solve it.
1. Two people are pushing a disabled car. One exerts a force of 200 N east, the other a force of 150 N east. What is the net force exerted on the car? (Assume friction to be negligible.)
 2. Two soccer players kick a ball simultaneously from opposite sides. Red #3 kicks with 50 N of force while Blue #5 kicks with 63 N of force. What is the net force on the ball?
 3. An airplane flies due north at 100 m/s through a 30 m/s cross wind blowing from the east to the west. Determine the resultant velocity of the airplane.
 4. A mountain climbing expedition establishes a base camp and two intermediate camps, A and B. Camp A is 11,200 m east of and 3200 m above base camp. Camp B is 8400 m east of and 1700 m higher than Camp A. Determine the displacement between base camp and Camp B.
 5. A plane flies with a velocity of 52 m/s east through a 12 m/s cross wind blowing the plane south. Find the magnitude and direction (relative to due east) of the resultant velocity at which it travels.
 6. An ambitious hiker walks 25 km west and then 35 km south in a day. Find the magnitude and direction (relative to due west) of her resultant displacement.
 7. A boat heads directly across a river with a velocity of 12 m/s. If the river flows at 6.0 m/s find the magnitude and direction (with respect to the shore) of the boat's resultant velocity.
 8. I went for a walk the other day. I went four avenues east (0.80 miles), then twenty-four streets south (1.20 miles), then one avenue west (0.20 miles), and finally eight streets north (0.40 miles).
 - a. What distance did I travel?
 - b. What's my resultant displacement?
 9. A plane intends to fly north with a speed of 250 m/s relative to the ground through a high altitude cross wind of 50 m/s coming from the east. Determine ...
 - a. the bearing that the plane should take (relative to due north) and
 - b. the plane's speed with respect to the air.
 10. At a particular instant, a stationary observer on the ground sees a package falling from a moving airplane with a speed v_{observer} at an angle θ to the vertical. To the pilot flying horizontally at a constant speed relative to the ground the package appears to be falling vertically with a speed v_{pilot} at that same instant. What is the speed of the pilot relative to the ground in terms of the given quantities?

AP Physics ~~1~~ Summer Assignment

Read all information carefully and complete all problems. You must show your work for the problems to receive credit. Work may be shown on a separate sheet of paper if necessary.

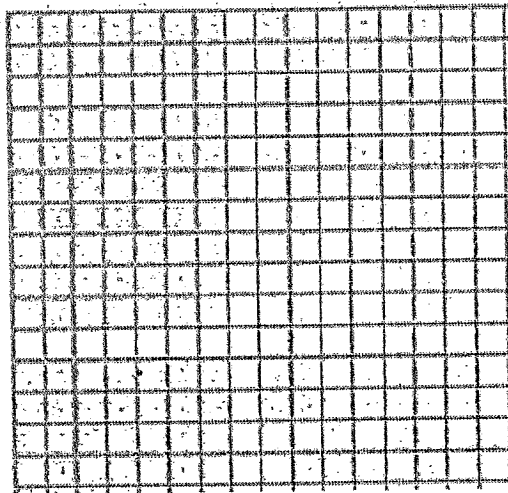
Graphing and Graph Interpretation

You should be familiar with graph construction (by hand and on a calculator). This is a topic that often appears on AP exams and is an easy way to score points on any assignment.

Note: When you are told to graph Apples vs. Oranges, the first thing goes on the y-axis. The second thing is on the x-axis.

Fill in the following table and plot the points on the grid below as distance versus time. Be sure to correctly label the graph (axes labels, including units, and title)

| Time, t (s) | Distance, d (m) |
|---------------|-------------------|
| 0.0 | 0 m |
| 1.0 | 5.1 m |
| 2.0 | 9.9 m |
| 3.0 | 15.2 m |



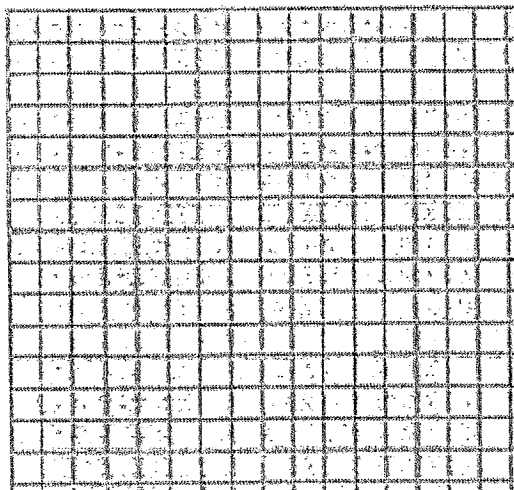
Draw the best fit line through your data points. Use a graphing calculator to plot the graph. Record the equation of the best-fit line. What is the slope of the line that you plotted (with correct units)?

AP Physics 1 Summer Assignment

Read all information carefully and complete all problems. You must show your work for the problems to receive credit. Work may be shown on a separate sheet of paper if necessary.

Plot position vs. time on the axes below.

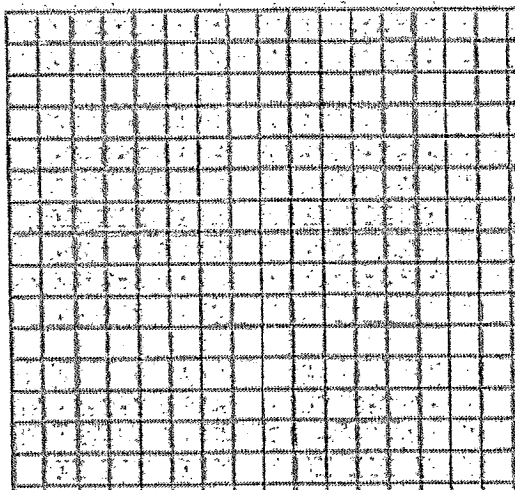
| Time | Position |
|-------|----------|
| 0.0 s | 0.0 m |
| 1.0 s | 4.1 m |
| 2.0 s | 15.8 m |
| 3.0 s | 36.2 m |



On your graphing calculator, create this plot and find the equation of the best fit curve. Record this best-fit equation below.

This graph has a changing slope. What does its slope represent?

This quadratic function can be "linearized" by squaring the time values, and plotting position vs. time squared. Try this with this data.



Find the equation of this best fit line on your graphing calculator. Record the equation of this best fit curve below.

Find the slope of this graph (use correct units). What does it represent?

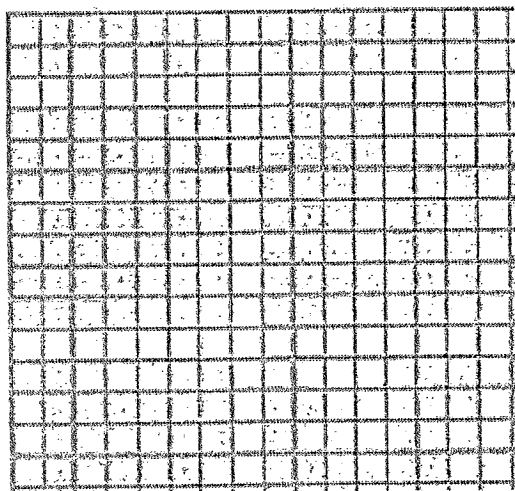
AP Physics II Summer Assignment

Read all information carefully and complete all problems. You must show your work for the problems to receive credit. Work may be shown on a separate sheet of paper if necessary.

Other function types.

The results of a class experiment investigating the relationship between mass and acceleration are shown in the table below. The force applied to each mass was the same.

| Mass (kg) | Acceleration (m/s^2) |
|-----------|--------------------------|
| 1.0 | 6.00 |
| 2.0 | 3.00 |
| 3.0 | 2.00 |
| 4.0 | 1.50 |
| 4.8 | 1.25 |
| 6.0 | 1.00 |



- Plot the values given and draw the curve that best fits the points.
- What is the relationship between mass and acceleration produced by a constant force (describe the plot you created in a.)?

- What can you say about the relationship between the values for mass and those for acceleration? Use a graphing calculator to find the equation of the best-fit curve to your data. Record it below.

AP Physics III Summer Assignment

Read all information carefully and complete all problems. You must show your work for the problems to receive credit. Work may be shown on a separate sheet of paper if necessary.

Algebra & Functions

A working knowledge of algebra is essential to success in physics. In AP Physics, there is more symbolic algebra, where symbols are used exclusively (no numbers!).

A direct proportion is a function whose graph is a non-horizontal line that passes through the origin. $y = kx$; k is the constant of proportionality

A linear function has a graph that is a non-horizontal line. $y = mx + b$; m is the slope of the line and b is the y -intercept. A direct proportion is a special case of a linear function, where $b = 0$.

A quadratic function has a graph that is a parabola. When y is proportional to x^2 , the graph goes through the origin and has a slope that increases as x increases. $y = ax^2 + bx + c$

An inverse relation has a graph that is a hyperbola (in the first quadrant). When y is proportional to $1/x$, the graph is asymptotic to the x and y axes. $y = k/x$

Identify the variable relationships.

1. $F = -kx$, (F vs. x) This function is _____, k
represents the _____ of the graph.
2. $U = mgh$, (U vs. h) This function is _____, mg
represents the _____ of the graph
3. $x = \frac{1}{2}at^2$ (x vs. t) This function is _____, Its
graph will look like _____, If x is
graphed vs. t^2 the slope will be _____.
4. $a = F/m$ (a vs. m). This function is _____, Its
graph will look like _____.

Solve the following. Show work for credit:

5. Solve for d : $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

6. Solve for a : $y = v_o t - \frac{1}{2}at^2$

7. Solve for θ_2 : $n_1 \sin \theta_1 = n_2 \sin \theta_2$

8. Solve for L : $T = 2\pi \sqrt{\frac{L}{g}}$

9. Solve for V_2 : $\frac{P_1 K_1}{T_1} = \frac{P_2 V_2}{T_2}$

*Memorize the equations w/ stars beside them. Quiz on the first day of class

ADVANCED PLACEMENT PHYSICS C EQUATIONS

MECHANICS

ELECTRICITY AND MAGNETISM

$v_x = v_{x0} + a_x t$
 $x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$
 $v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$
 $\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$
 $\vec{F} = \frac{d\vec{p}}{dt}$
 $\vec{J} = \int \vec{F} dt = \Delta\vec{p}$
 $\vec{p} = m\vec{v}$
 $|\vec{F}_f| \leq \mu |\vec{F}_N|$
 $\Delta E = W = \int \vec{F} \cdot d\vec{r}$
 $K = \frac{1}{2} m v^2$
 $P = \frac{dE}{dt}$
 $P = \vec{F} \cdot \vec{v}$
 $\Delta U_g = mg\Delta h$
 $a_c = \frac{v^2}{r} = \omega^2 r$
 $\vec{\tau} = \vec{r} \times \vec{F}$
 $\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$
 $I = \int r^2 dm = \sum mr^2$
 $x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$
 $v = r\omega$
 $\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$
 $K = \frac{1}{2} I\omega^2$
 $\omega = \omega_0 + \alpha t$
 $\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$

a = acceleration
 E = energy
 F = force
 f = frequency
 h = height
 I = rotational inertia
 J = impulse
 K = kinetic energy
 k = spring constant
 ℓ = length
 L = angular momentum
 m = mass
 P = power
 p = momentum
 r = radius or distance
 T = period
 t = time
 U = potential energy
 v = velocity or speed
 W = work done on a system
 x = position
 μ = coefficient of friction
 θ = angle
 τ = torque
 ω = angular speed
 α = angular acceleration
 ϕ = phase angle

$\vec{F}_s = -k\Delta\vec{x}$
 $U_s = \frac{1}{2} k(\Delta x)^2$
 $x = x_{max} \cos(\omega t + \phi)$
 $T = \frac{2\pi}{\omega} = \frac{1}{f}$
 $T_s = 2\pi \sqrt{\frac{m}{k}}$
 $T_p = 2\pi \sqrt{\frac{\ell}{g}}$
 $|\vec{F}_G| = \frac{Gm_1 m_2}{r^2}$
 $U_G = -\frac{Gm_1 m_2}{r}$

$|\vec{F}_E| = \frac{1}{4\pi\epsilon_0} \left| \frac{q_1 q_2}{r^2} \right|$
 $\vec{E} = \frac{\vec{F}_E}{q}$
 $\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$
 $E_x = -\frac{dV}{dx}$
 $\Delta V = -\int \vec{E} \cdot d\vec{r}$
 $V = \frac{1}{4\pi\epsilon_0} \sum_i \frac{q_i}{r_i}$
 $U_E = qV = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r}$
 $\Delta V = \frac{Q}{C}$
 $C = \frac{\kappa\epsilon_0 A}{d}$
 $C_p = \sum_i C_i$
 $\frac{1}{C_s} = \sum_i \frac{1}{C_i}$
 $I = \frac{dQ}{dt}$
 $U_C = \frac{1}{2} Q\Delta V = \frac{1}{2} C(\Delta V)^2$
 $R = \frac{\rho\ell}{A}$
 $\vec{E} = \rho\vec{J}$
 $I = Nev_d A$
 $I = \frac{\Delta V}{R}$
 $R_s = \sum_i R_i$
 $\frac{1}{R_p} = \sum_i \frac{1}{R_i}$
 $P = I\Delta V$

A = area
 B = magnetic field
 C = capacitance
 d = distance
 E = electric field
 \mathcal{E} = emf
 F = force
 I = current
 J = current density
 L = inductance
 ℓ = length
 n = number of loops of wire per unit length
 N = number of charge carriers per unit volume
 P = power
 Q = charge
 q = point charge
 R = resistance
 r = radius or distance
 t = time
 U = potential or stored energy
 V = electric potential
 v = velocity or speed
 ρ = resistivity
 Φ = flux
 κ = dielectric constant

$\vec{F}_M = q\vec{v} \times \vec{B}$
 $\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I$
 $d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{\ell} \times \hat{r}}{r^2}$
 $\vec{F} = \int I d\vec{\ell} \times \vec{B}$
 $B_s = \mu_0 n I$
 $\Phi_B = \int \vec{B} \cdot d\vec{A}$
 $\mathcal{E} = \oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$
 $\mathcal{E} = -L \frac{dI}{dt}$
 $U_L = \frac{1}{2} LI^2$