AP PHYSICS C
AIR ACADEMY HIGH SCHOOL
MR. BOYLE ROOM 417
SUMMER ASSIGNMENT 2019-2020

NAME_____

CLASS INFORMATION:

Welcome to the joy of a calculus-based physics class. It is a challenging class, but it is rewarding, as you see a deep application of the calculus that you learn. The AP Physics C exams are unique in that it has two exams (Mechanics and E/M) that are 90 minutes apiece held in the afternoon of Mon. May 4, 2020. First semester we will study mechanics and second semester electricity and magnetism. Due to this being the first AP Exam, expect virtual lessons on Snow Days and testing schedules. You may choose to take either or both exams based upon what your college accepts and comfort level. Calculators are allowed in both the multiple-choice and free-response sections. Each exam has 35 multiple-choice questions and three free-response questions worth 15 points apiece. The textbook we will use is *Halliday, Resnick, and Walker's Fundamentals of Physics (8th edition)* (2008) ISBN 978-0-470-04472-8. I will pass this book out in the fall because of additions/deletions of students over the summer. Throughout the class, I will use book problems and post solutions on-line so that you can better prepare for quizzes and exams.

OBJECTIVES OF SUMMER ASSIGNMENT:

(1) Remind yourself of the basic mathematics to learn calculus problems.

(2) Learn or review basic calculus concepts that you will be exposed to in the first unit.

(3) Remind yourself of material covered in Honors Physics.

Be patient with yourself if you are new to Calculus or Physics. Calculus will be taught in the context of Physics.

WEBSITE:

Schoology account will be accepted in the fall.

QUESTIONS ABOUT THE PACKET OR THE CLASS?

Please e-mail me: brad.boyle@asd20.org

I check my e-mail over the summer and will reply within a week.

This assignment will be due the second block of class to allow for any questions. Answers will be posted on my Schoology website the first day of class so that you can check your answers.

DIRECTIONS: Please complete the summer assignment on your own paper, showing work.

Part 1: Equation Tables

Print out the attached AP Physics C exam equation sheet. **Identify** the equations that you are familiar with. **Group** the equations that seem related. On the first day of class, I will have a laminated sheet of equations that you will need to refer throughout the course. The AP exam now allows you to use the equation sheet for all parts of the exam.

Part II: Completion of Google Survey for AP Physics

Find and take the Google survey linked to my teacher page on the AAHS website. It is also linked here.
https://goo.gl/forms/KJlq0jfu7rIdLCSW2

Part III: Math review – Vector Algebra, Calculus, Separation of Variables & Differential Equations

Algebra: Manipulation of formulas and equations is essential for success in solving Physics problems.

1. Solve for x

$$4x - 3 = 17$$

2. Solve for x

$$0.8 - 0.52x = 0.98x + 5.3$$

3. Solve for y

$$y^2 - 3y = 10$$

4. Solve for x and y (Systems of Linear Equations)

$$8x - 3y = -3$$
$$4x - 2y = -4$$

5. Solve for z

$$3 = \sqrt{z + 2}$$

6. Solve for d (Most of Physics is solved symbolically)

$$c + \frac{b}{d} = a$$

7. Use the internet to define and explain **dot product** and **cross product**. How are these concepts applied to physics?

Part III: Significant Figures and Scientific Notation: For accuracy purposes and ease of writing.

Indicate the number of significant figures and express in scientific notation (rounded to 2 decimal places)

1. 0.0845 kg
2. 8630000.000 mi
3. 2.9910 m
4. 5600 km
5. 809 g

Solve the following problems and give the answer in the correct number of significant digits & units.

6. 2.674 m / 2.0 m = _____
7. 5.25 m x 1.3 m = _____
8. 9.0 cm + 7.66 cm + 5.44 cm = _____
9. $(3.0 \times 10^{4})(34.5 \times 10^{12})$ = _____
10. $(2.64 \times 10^{6})/(5.67 \times 10^{-3})$ = _____

Write the following out in decimal form

11. 1.23×10^{-5}
12. 7.543×10^{6}

Part IV: Conversions: Important because there are several different systems of measure with variations of measurements within each. When calculating, the measurements must be compatible (unit or dimension analysis).

1. Convert 4.4 km/h to m/s.
2. Convert 8.76×10^{7} MW to GW:
3. Convert 2.5 days to s:
4. Convert 22 mg to kg
5. 1 h to s
6. One light year is the distance light travels in one year. This distance is equal to 9.461×10^{15} m. The star Alpha Centuri, which is the nearest star to Earth that is visible to the unaided eye, is about 4.35 light years away. Express this distance in
   a. Gigameters
   b. Picometers

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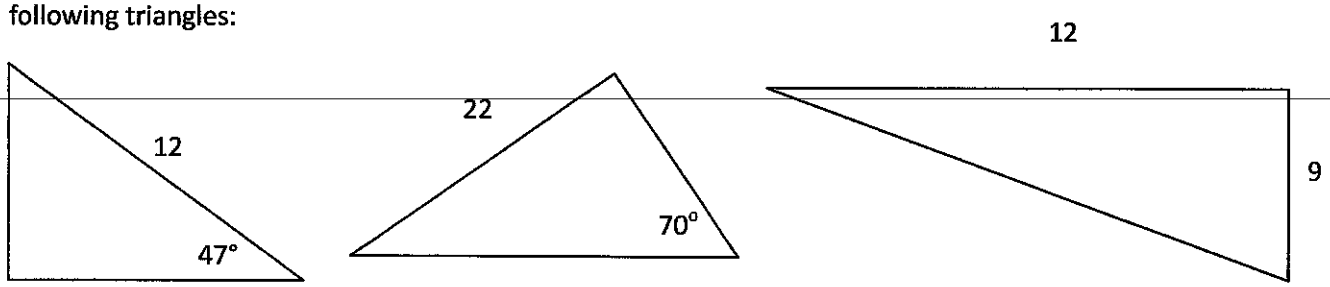
Part V: Trigonometry: Important to break things into their component vectors. Find the missing sides and angles in the following triangles:



Part VI: Vectors

Most of the quantities in physics are vectors. ***This makes proficiency in vectors extremely important***.

Magnitude: Size or extend. The numerical value.

Direction: Alignment or orientation of any position with respect to any other position.

Scalars: A physical quantity described by a single number and units. A quantity described by **magnitude only**.

Examples: time, mass, and temperature

Vector: A physical quantity with **both a magnitude and a direction**. A directional quantity.

Examples: velocity, acceleration, force

Notation: $\vec{A}$ or $\overrightarrow{A}$

Length of the arrow is proportional to the vectors magnitude.

Direction the arrow points is the direction of the vector.

Direct your browser to the following website. Read through and try to understand the four examples given. The course will begin with a vector problem in context of the material learned. If this is an unfamiliar process, you should be able to pick it up after a few examples. Again, be patient with yourself.

http://physics.info/vector-components/practice.shtml

Part VII: Calculus

For those of you new to calculus, I would suggest the following links. Be patient with yourself if you are! AP Physics uses very elementary calculus which will be taught in the context of the course.

(1) Look at Khan Academy videos over the topics listed below.

(2) Purchase the book *Quick Calculus* Daniel Klepper and Norman Ramsey on Amazon (ISBN 0-471-82722-3)

(3) Learn about the concept of limit

http://www.analyzemath.com/calculus/limits/introduction.html

http://tutorial.math.lamar.edu/Classes/CalcI/DefnOfLimit.aspx

Power-Rule Derivatives

For each of the following functions, find the derivative (dy/dx) with respect to x:

1. $y = 5x^2$ 2. $y = 4x$ 3. $y = 8x^3$

4. $y = 2$ 5. $y = 2x^{-1}$ 6. $y = 4x^3 + 2x - 1$

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Other common derivatives

For each of the following functions, find the derivative (dy/dx) with respect to x:

7. $y = \cos x$ 8. $y = e^x$ 9. $y = \ln x$

Chain Rule

Use the chain rule to help you find dy/dx for each of the following functions:

10. $y = (x^2 + 4)^3$ 11. $y = e^{3x}$ 12. $y = \sin(3x+1)$

Product Rule Derivatives

Use the product rule to help you find dy/dx for each of the following functions:

13. $y = (x^2)(2x - 7)$ 14. $y = 2x^3e^x$ 15. $y = (5x^2 + 3x)(\ln x)$

Maximum and Minimum Values

Find the maximum y-coordinate reached by the following functions:

16. $y = -3x^2 + 12x$ 17. $y = -2x^2 - 20x + 12$

Indefinite Integrals

Use the idea of "un-doing a derivative" to find the following indefinite integrals:

18. $\int 3x^2 dx$ 19. $\int (8x^3 + 2x)dx$ 20. $\int (5x^3 - 1)dx$

Definite Integrals

Evaluate each of the following definite integrals:

21. $\int_0^2 (6x^2 + 3)dx$ 22. $\int_1^5 (4x + 1)dx$

Calculus and Graphs

Use calculus ideas to find the required graphical values of the following functions:

23. Find the instantaneous slope of the function y = x2 + 3x – 5 at the point (2, 5).

24. For the same function used in the previous problem, find the area under the curve between x=0 and x=2.

Part VIII: Kinematics

Now you are going to attempt to remember the physics that you learned in prior courses. If you are a bit rusty, the following websites are provide good explanation of things covered in first year physics.

http://www.physicsclassroom.com/class (The Physics Classroom)

http://www.ck12.org/physics/ (C K-12)

1. An object is traveling at a constant velocity of 11 m/s when it experiences a constant acceleration of 1.5 m/s^2 for a time of 14 s. What will its velocity be after that acceleration?

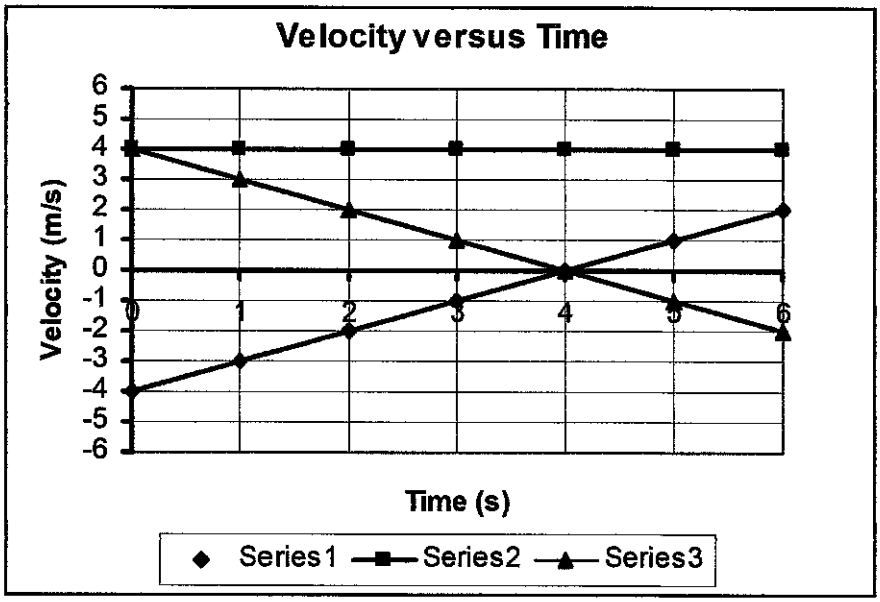
2. An object is thrown vertically up with a velocity of 35 m/s. What was the maximum height it reached?

3. A boy throws a ball vertically up and catches it after 3 s. What height did the ball reach?

4. An object is moving at a velocity of 5.8 m/s. It accelerates to a velocity of 25 m/s over a time of 3.3 s. What acceleration did it experience?

5. A car which is traveling at a velocity of 9.6 m/s undergoes an acceleration of 4.2 m/s^2 over a distance of 450 m. How fast is it going after that acceleration?

6. The velocity versus time graph, right, describes the motion of three different cars moving along the x-axis.



   a. Describe, in words, the velocity of each of the cars. Make sure you discuss each car's speed and direction.

   b. Calculate the displacement of each car during its 6 s trip.

   c. Calculate the distance traveled by each car during its 6 s trip.

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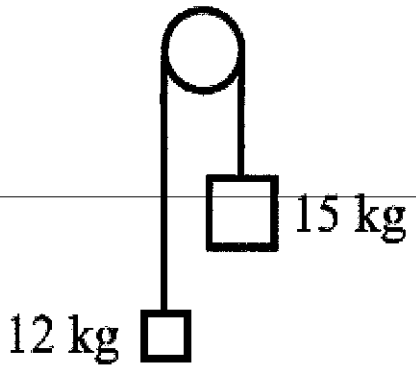
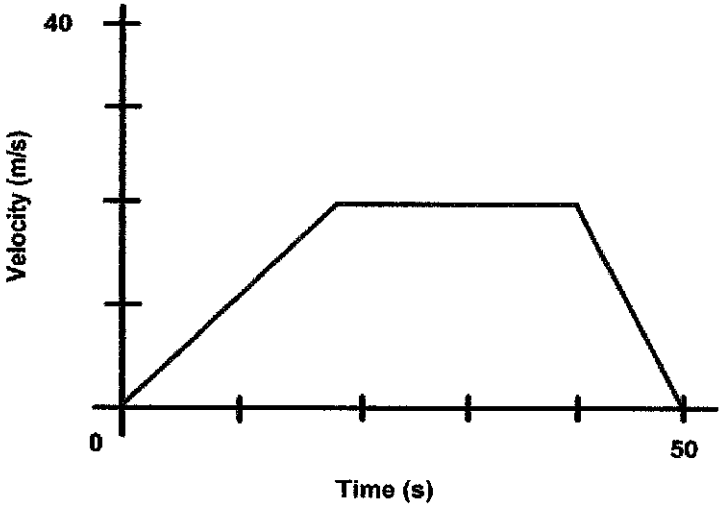
Part IX: Dynamics

7. A 12 kg load hangs from one end of a rope that passes over a small frictionless pulley. A 15 kg counterweight is suspended from the other end of the rope. The system is released from rest.



   a. Draw a free-body diagram for each object showing all applied forces in relative scale. Next to each diagram show the direction of the acceleration of that object. (*This is not entered on the google form*)
   b. Find the acceleration each mass.
   c. What is the tension force in the rope?
   d. What distance does the 12 kg load move in the first 3 s?
   e. What is the velocity of 15 kg mass at the end of 5 s?

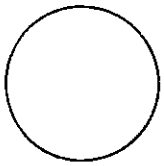
8. A 2000 kg car travels in a straight line on a horizontal road. The relationship between car's velocity and the time are given by the above graph.



   a. What is the car's acceleration during first 20 s?
   b. What is the net force applied by the engine during the first 20 s?
   c. What is the car's acceleration from 20 s to 40 s?
   d. What is the net force applied by the engine during this time?
   e. What is the car's acceleration from 40 s to 50 s?
   f. What is the net force applied by an engine during this time?

Part X: Universal Law of Gravitation

9. As shown in the diagram below, a 1000 kg asteroid is located 6.8×10^6 m from the center of the Mars. The mass of the Mars is 6.4×10^{23} kg.



Mars

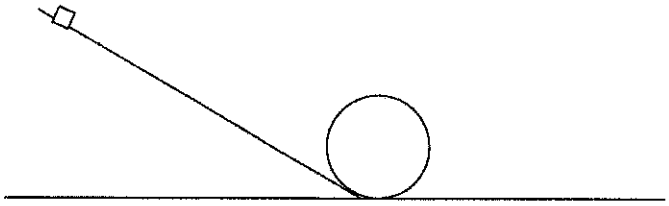
Asteroid

a. Determine the force of gravity acting on the asteroid, due to the Mars. Calculate the magnitude and state the direction.

b. Compare your answer in a) to the force of gravity acting on the Mars, due to the asteroid. Indicate that force on the diagram above.

c. Calculate the acceleration the asteroid would experience.

Part XI: Work and Energy

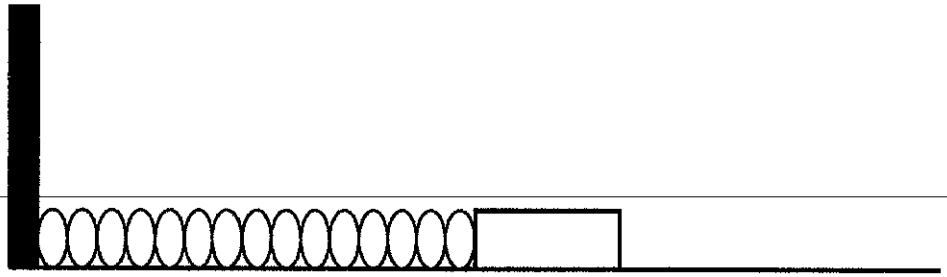


10. A small block, with a mass of 250 g, starts from rest at the top of the apparatus shown above. It then slides without friction down the incline, around the loop and then onto the final level section on the right. The maximum height of the incline is 80 cm, and the radius of the loop is 15 cm.

a. Find the initial potential energy of the block

b. Find the velocity the block at the bottom of the loop

c. Find the velocity of the block at the top of the loop.



11. A 0.8 kg block is attached to the end of a spring whose spring constant is 85 N/m. The block is placed on a frictionless tabletop, given an initial displacement of 3.5 cm and then released.

    a. What type of energy did the block-spring system initially have?
    b. Find the magnitude of this energy.
    c. How does the total energy of the block-spring system change as the block is pushed across the frictionless surface? Explain.
    d. Find the maximum velocity of the block.

Part XII: Momentum

12. A bullet of mass 0.01 kg is moving horizontally with a speed of 100 m/s when it hits a block of mass 2 kg that is at rest on a horizontal surface. After the collision the bullet becomes embedded in the block.

    a. What is the momentum of the bullet before the collision?
    b. What is the momentum of the bullet-block system after the collision?
    c. What is the speed of the bullet-block system after the collision?
    d. Find the **total** kinetic energy of the bullet and block before the collision?
    e. Find the kinetic energy of the bullet-block system after the collision?
    f. Is the total energy conserved during the collision?

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Part XIII: AP Graphing Exercise (Linearization of Data)

29). To prepare for one of the first activities of the year, watch the following video on how to linearize data from Mr. Nuna's AP Physics 1 page. Do not worry about the second video.

https://sites.google.com/site/apphysics1online/appendices/2-data-analysis/graph-linearization

This video shows how to analyze data in Google Sheets.

https://www.mrwaynesclass.com/labs/reading/index06.html

After you watched the video, please linearize the following question by using Excel or Google Sheets.

Time (s)	Time ^2 (s^2)	Distance (m)
0.00	0.00	0.00
1.00	1.00	6.90
2.00	4.00	23.60
3.00	9.00	50.10
4.00	16.00	86.40
5.00	25.00	132.50
6.00	36.00	188.40
7.00	49.00	254.10
8.00	64.00	329.60
9.00	81.00	414.90
10.00	100.00	510.00

There is an equation in physics to describe free-fall motion $y = \frac{1}{2} g t^2$, where g is the acceleration of gravity in (m/s^2), y is the vertical distance of drop in meters, and time is in seconds.

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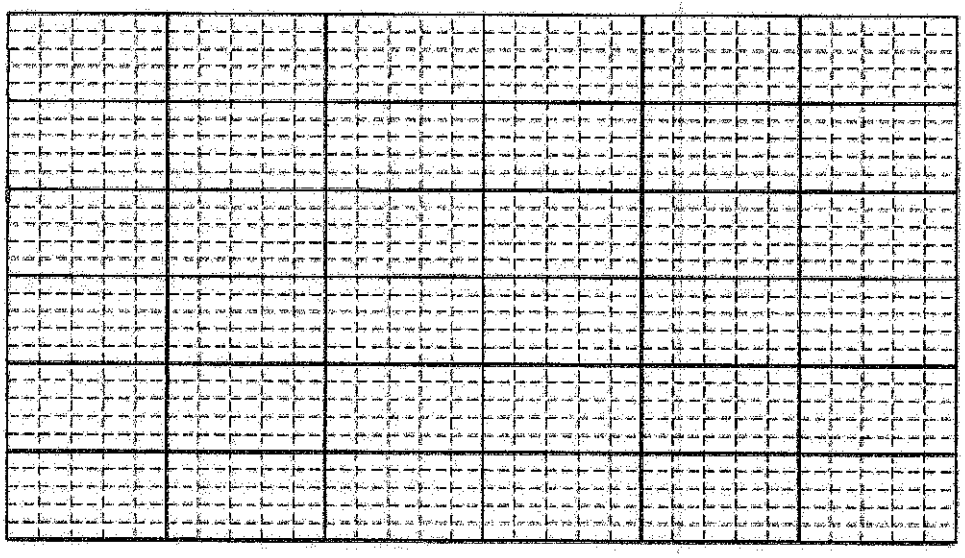
Plot y vs t^2 on the graph below.



Find the slope of this graph.

The slope is equal to ½ g. Find g by multiplying the slope by 2.

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ADVANCED PLACEMENT PHYSICS C EQUATIONS DEVELOPED FOR 2012

MECHANICS

$v = v_0 + at$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$v^2 = v_0^2 + 2a(x - x_0)$

$\Sigma \mathbf{F} = \mathbf{F}_{net} = m\mathbf{a}$

$\mathbf{F} = \frac{d\mathbf{p}}{dt}$

$\mathbf{J} = \int \mathbf{F}\,dt = \Delta\mathbf{p}$

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

$F_{fric} \le \mu N$

$W = \int \mathbf{F} \cdot d\mathbf{r}$

$K = \frac{1}{2}mv^2$

$P = \frac{dW}{dt}$

$P = \mathbf{F} \cdot \mathbf{v}$

$\Delta U_g = mgh$

$a_c = \frac{v^2}{r} = \omega^2 r$

$\tau = \mathbf{r} \times \mathbf{F}$

$\Sigma \tau = \tau_{net} = I\alpha$

$I = \int r^2 dm = \Sigma mr^2$

$r_{cm} = \Sigma mr / \Sigma m$

$v = r\omega$

$\mathbf{L} = \mathbf{r} \times \mathbf{p} = I\boldsymbol{\omega}$

$K = \frac{1}{2}I\omega^2$

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

a = acceleration
F = force
f = frequency
h = height
I = rotational inertia
J = impulse
K = kinetic energy
k = spring constant
ℓ = length
L = angular momentum
m = mass
N = normal force
P = power
p = momentum
r = radius or distance
$\mathbf{r}$ = position vector
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

$\mathbf{F}_s = -k\mathbf{x}$

$U_s = \frac{1}{2}kx^2$

$x = x_{max}\cos(\omega t + \phi)$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$\mathbf{F}_G = -\frac{Gm_1m_2}{r^2}\hat{\mathbf{r}}$

$U_G = -\frac{Gm_1m_2}{r}$

ELECTRICITY AND MAGNETISM

$F = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}$

$\mathbf{E} = \frac{\mathbf{F}}{q}$

$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q}{\epsilon_0}$

$E = -\frac{dV}{dr}$

$V = \frac{1}{4\pi\epsilon_0}\sum_i \frac{q_i}{r_i}$

$U_E = qV = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r}$

$C = \frac{Q}{V}$

$C = \frac{\kappa\epsilon_0 A}{d}$

$C_p = \sum_i C_i$

$\frac{1}{C_s} = \sum_i \frac{1}{C_i}$

$I = \frac{dQ}{dt}$

$U_C = \frac{1}{2}QV = \frac{1}{2}CV^2$

$R = \frac{\rho\ell}{A}$

$\mathbf{E} = \rho\mathbf{J}$

$I = Nev_dA$

$V = IR$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$P = IV$

$\mathbf{F}_M = q\mathbf{v} \times \mathbf{B}$

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 = distance
t = time
U = potential or stored energy
V = electric potential
v = velocity or speed
ρ = resistivity
Φ_m = magnetic flux
κ = dielectric constant

$\oint \mathbf{B} \cdot d\boldsymbol{\ell} = \mu_0 I$

$d\mathbf{B} = \frac{\mu_0}{4\pi}\frac{I\,d\boldsymbol{\ell} \times \mathbf{r}}{r^3}$

$\mathbf{F} = \int I\,d\boldsymbol{\ell} \times \mathbf{B}$

$B_s = \mu_0 nI$

$\Phi_m = \int \mathbf{B} \cdot d\mathbf{A}$

$\mathcal{E} = \oint \mathbf{E} \cdot d\boldsymbol{\ell} = -\frac{d\Phi_m}{dt}$

$\mathcal{E} = -L\frac{dI}{dt}$

$U_L = \frac{1}{2}LI^2$

ADVANCED PLACEMENT PHYSICS C EQUATIONS DEVELOPED FOR 2012

GEOMETRY AND TRIGONOMETRY

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$

$C = 2\pi r$

Rectangular Solid

$V = \ell wh$

Cylinder

$V = \pi r^2 \ell$

$S = 2\pi r\ell + 2\pi r^2$

Sphere

$V = \frac{4}{3}\pi r^3$

$S = 4\pi r^2$

A = area
C = circumference
V = volume
S = surface area
b = base
h = height
ℓ = length
w = width
r = radius

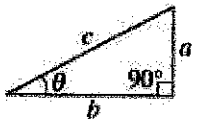
Right Triangle

$a^2 + b^2 = c^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



CALCULUS

$\frac{df}{dx} = \frac{df}{du}\frac{du}{dx}$

$\frac{d}{dx}(x^n) = nx^{n-1}$

$\frac{d}{dx}(e^x) = e^x$

$\frac{d}{dx}(\ln x) = \frac{1}{x}$

$\frac{d}{dx}(\sin x) = \cos x$

$\frac{d}{dx}(\cos x) = -\sin x$

$\int x^n dx = \frac{1}{n+1}x^{n+1}, n \neq -1$

$\int e^x dx = e^x$

$\int \frac{dx}{x} = \ln|x|$

$\int \cos x\, dx = \sin x$

$\int \sin x\, dx = -\cos x$

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