AP Physics 1 – Summer Review (due the 3rd day of school)

Name ______________________________

As noted in the title, this packet is due at the beginning of class on the third day of school (Wednesday, August 31, 2016). It will count for 5 to10 percent of your grade for the first quarter. The packet will be collected at the start of class, scored, and returned to you the next day when we go over the answers. There will be a quiz on the content covered in the packet the next day, Friday, Sept. 2nd (another 5 to 10 percent of your grade for the first quarter).

The packet is a math review to brush up on necessary skills, and perhaps as a means to assess whether you are correctly placed in Advanced Placement Physics. The study of physics, and AP Physics in particular, requires proficiency in algebra, trigonometry, and geometry. The following assignments require the use of mathematical techniques that are considered routine in AP Physics. This includes knowledge of the metric system along with the use of scientific notation and conversion factors within the metric system (ex. 120g = ? kg). The ability to algebraically manipulate physics formulae is a second key area of math application. Finally, a basic knowledge of vector addition, subtraction, and multiplication both graphically and using right triangle geometry is needed.

If you have had the course work and are comfortable with these topics and skills, you should be able to complete this packet in a couple of hours. If you feel deficient in these subjects, it is strongly advised that you review your algebra, trigonometry, and geometry skills over the summer. There are many excellent resources on the internet. Two of the best are The Physics Classroom and Khan Academy, but there are many others and you can always turn to YouTube for multiple lessons about the same topic.

AP Physics 1 is not just a college-level course, it is a *college course*. To that end, it is challenging both in its breadth and depth. The last page of this packet has the list of the equations that you are responsible for (and can refer to) when you take the AP exam. However, the course (and the test) is not simply about plugging numbers into equations and solving for an unknown variable. It is about interpreting those equations as they apply to real-world situations and using the math to write about those situations.

To that end, I will do as much as I can to *help* you learn, but *you* and you alone are responsible for learning and understanding everything covered in class.

I will give you assignments and tests along with due dates, but I will not chase after you. If you are absent, it is your responsibility to access my Canvas page (I update it every day) to see what I collected, scored, and/or handed out, what was covered in class, and what was for homework. Do not assume I will ask you for it.

So, welcome to AP Physics 1. It is an interesting, exciting, rewarding, and challenging course that may turn out to be your favorite course in high school.

Mr. Dubac

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I. Algebra and Trig Review

We will use basic algebra and trig throughout the year to solve physics problems. We'll learn several equations that describe the relationships among variables. Depending on what information is known in a given situation, you may need to rearrange the equation to solve for the unknown of interest. We'll also have to use trig to find the magnitude (fancy word for amount) of a variable in the direction of interest. You'll want to be comfortable with these skills. Review the Algebra & Trig summary pages. Complete the practice problems.

II. Vectors

Many of the quantities in Physics are vectors, which mean they have both magnitude and direction. For example, to fully describe the velocity at which you are traveling you might say that you are traveling at 10 m/s west. Force is another example of a vector. The direction of a force is important. For example, if you are trying to push a stalled car, you would certainly want to apply the force in the direction that you want the car to travel.

You need to show your work to receive credit – don't just write down the answer!

III. Graphing

Graphing is a major component of the development of physics concepts and allows us to create mathematical models for the phenomena we investigate. Being able to create a graph, read a graph and linearize data is essential for your success in this course.

Part I: Algebra Review

Throughout the year, we'll be rearranging formulas and equations to solve for the variable we want to know. Refresh your algebra skills with the following:

Example:

Suppose we want to know the acceleration, a, in the following formula: $\Delta y = v_o t + \frac{1}{2}at^2$

y is the distance

v_o is the initial velocity

t is the time

Isolate the term with the variable of interest, a.

$\Delta y = v_o t + \frac{1}{2}at^2$

$\Delta y - v_o t = \frac{1}{2}at^2$

$\frac{\Delta y - v_o t}{\frac{1}{2}t^2} = a$

Example:

Solve the following.

$6 = \frac{18+3x}{x}$

In this case, we have to get all the terms with x's into 1 term.

Multiply both sides by x.

$6x = 18 + 3x$

$6x - 3x = 18 \;\; 3x = 18$

Divide both sides by 3

$x = 6$

Practice: Solve the following for the unknown variable.

1. $x + 47 = 95$
2. $55 + a = \; -78$
3. $\frac{1}{r} = \frac{1}{5} + \frac{1}{15}$
4. $\frac{1}{32} = \frac{1}{f} + \frac{1}{-8}$
5. $37 = \frac{314.5}{x}$
6. $5 = \frac{3x-4}{x}$
7. $2x = \frac{3x^2 - 16}{x}$

Practice: Solve for the given letter (variable)

1. $A = p + prt$ for t
2. $A = \frac{1}{2} d_1 d_2$ for d_1
3. $f_o = \frac{f_s(v+v_0)}{v-v_s}$ for v_o
4. $y = mx + b$ for m

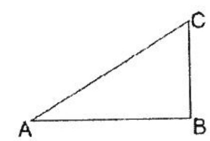
5. $v = \sqrt{(\frac{GM}{r})}$ for r

6. $F = k\frac{Q_1Q_2}{r^2}$ for r

7. $F = \frac{mv^2}{r^2}$ for v

Right Triangles & Trigonometry

Suppose you wanted to get from point A to point C in the following diagram. You could go directly from A to C, or you could go to the right from A to B and then go straight up from B to C. Thus the direction we go is important. We will define the distance from C to A as our displacement. You'll see shortly that the displacement is a vector. In many cases, we will be interested in the x and y component of a vector. In this case, the x component is AB. The y component is BC.



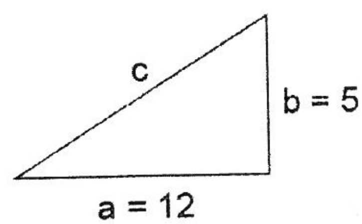
Pythagorean Theorem

If two of the three sides of a right triangle are known, we can find the 3rd side using the Pythagorean Theorem. Recall that $a^2 + b^2 = c^2$

Example:

Find C for the triangle shown right.

$$a^2 + b^2 = c^2 \quad 12^2 + 5^2 = c^2 \quad 169 = c^2 \quad c = 13$$



Right Triangle Trigonometry

Both of the triangles shown are right triangles. Angle is the same for both. Side **c** is the hypotenuse.

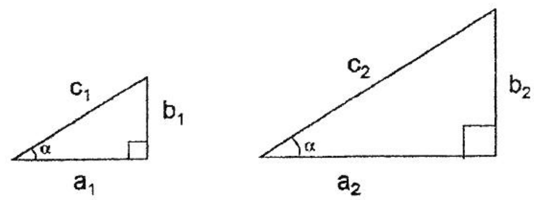
Side **a** is adjacent to angle.

Side **b** is opposite angle.

If we divided side **b** by side **a** for both triangles we would get the same number. The only way we could get a different ratio would be if the angle changed.

For example, if the angle increased, side **b** would have to increase, while side **a** remained the same. That would cause the ratio to increase. We call the ratio of side **b** to side **a** the tangent of the angle. The same logic is true for the ratios of any two sides. We will use three ratios:

$\sin\alpha = \frac{b}{c}$ $\cos\alpha = \frac{a}{c}$ $\tan\alpha = \frac{b}{a}$

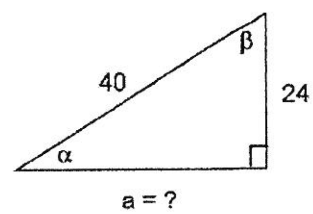


Practice: Solve the following.

1. What is the length of side a?

2. What is the sine of angle α?

3. What is the cosine of angle α?

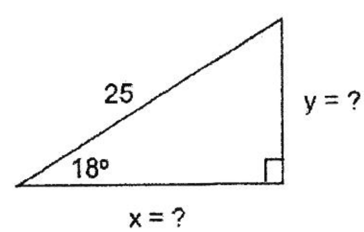


4. Angle α = __________ degrees

5. Angle β = ___________degrees.

Practice: Solve the following.

1. What is the length of side x?



2. What is the length of side y?

3. Use Pythagorean Theorem to check your answers.

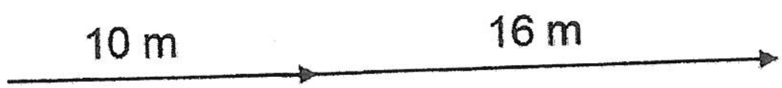
The values for x and y are called the "components" of the vector 25 units at 18 degrees North East. We will be using components all year!

Part II: Vector Addition and Subtraction

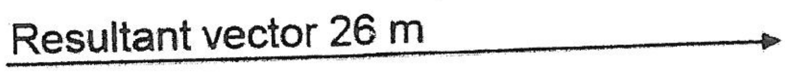
Vectors have both magnitude and direction, thus we must take the direction into account when adding or subtracting vectors.

Adding Vectors:

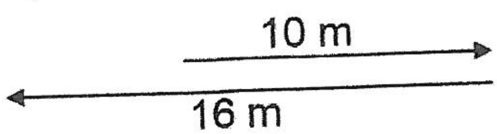
1. The simplest case occurs when vectors are collinear. Vectors are normally represented by arrows. When adding, we used a tail-to-head relationship. Thus the tail of the vector being added to the original vector is placed at the head of the original vector. If they are in the same direction, simply add the magnitudes of the vectors. The direction will be the same as that of the individual vectors.
   For example, if someone walked 10 m East and then 16 meters East, we would draw the vectors as:



The resultant vector would be 26 m East. It is drawn from the tail of the first vector to the head of the second one.

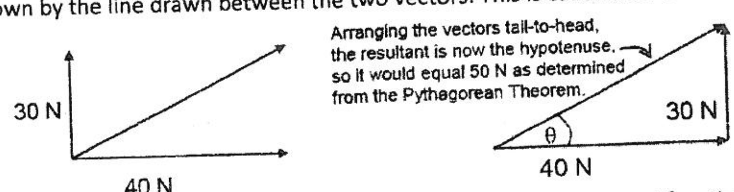


If vectors are in the opposite direction, add them, keeping in mind they have opposite signs.



The resultant vector would be 6 m West.

2. The next simplest case occurs when vectors are perpendicular to each other.. We use the Pythagorean Theorem to add these vectors. For example, if we had a force of 40 N pushing an object due West and a force 30 N pushing an object due North, we know the object would move along a path between the two forces as shown by the line drawn between the two vectors. This is called the **resultant**.



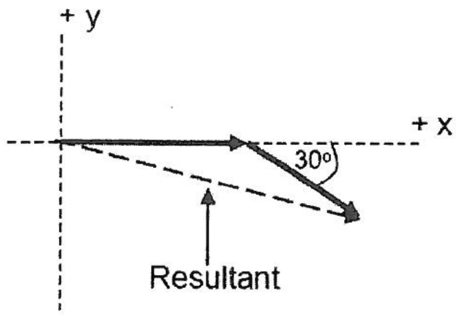
To find the angle, θ, that the resultant force acts along, we can use the inverse tangent function.
$\theta = tan^{-1}\left(\frac{30}{40}\right)$, $\theta = 37°$ above the horizontal

This tells us that the two original forces could be replaced by a single force of 50N acting at 37° above the horizontal. The 50N force at 37° is the sum of the original forces. This is the **resultant vector**.

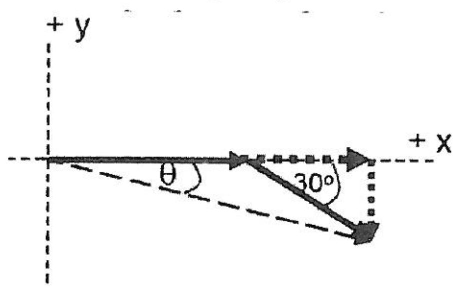
Adding Vectors that are not collinear and not perpendicular:

To add vectors such as 70 m due E to 50 m at 30°S of E, we need to break the vectors into x-y components.

1. Start by drawing a picture. Don't skip this step; it will help you avoid direction errors.
2. Set up an x-y system. Label the positive and negative directions.



3. Use trig to determine the x and y components of the vector. Be sure to take directions into account by using + and –signs.
   a. The 70 meter vector lies along the +x axis. Its x component is its full length, 70m and it has no y component.
   b. The 50 meter vector must be broken into components. Draw the components in the x and y direction to make a right triangle. The original vector is the hypotenuse.
   c. The x component of the 50 m vector can be found using the cosine function in this case. The y component can be found using the sine function Note the negative sign since we are going in the negative y direction.



Cos 30 = x/50, so x = 50 cos30 = 43.3 m

Sin 30 = -y/50, so y = -50 sin30 = -25 m

> Note: the x component won't always be cosine. It depends on the angle you use.

4. Make a table to organize your data.
5. Add the x components and the y components.
6. Use the Pythagorean Theorem to determine the resultant vector.

Vector	x	y
70 m	70	0
50 m	43.3	-25
Resultant	113.3	-25

$$\sqrt{(113.3^2+25^2)} = 116\ m$$

7. Use the inverse tan function to find the angle.

$$\theta = tan^{-1}\left(\frac{25}{113.3}\right) = 12.4°$$

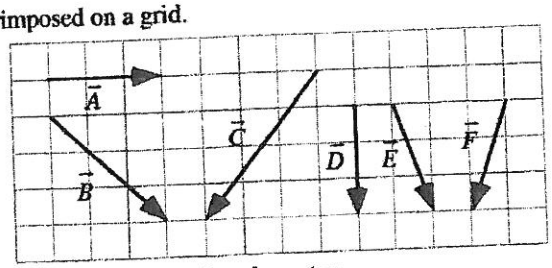
Practice: Find the magnitude of resultant vector for the following pairs of vectors. Show your answers with both a drawing and mathematics.

1. A 15 m/s vector East added to a 20 m/s vector West

2. A 40 m vector East added to a 60 m vector North

3. A 15 m vector @ 45degrees NE added to a 10 m vector @ 30 degrees SE

Shown below are vectors superimposed on a grid.



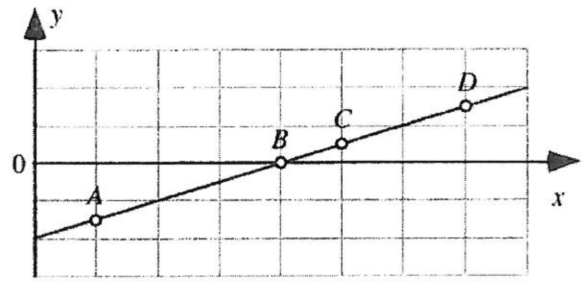
(a) Rank the magnitudes of the *x*-components of each vector.

						OR			
1 Greatest	2	3	4	5	6 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Part III: Graphing

Four points are labeled on a line.

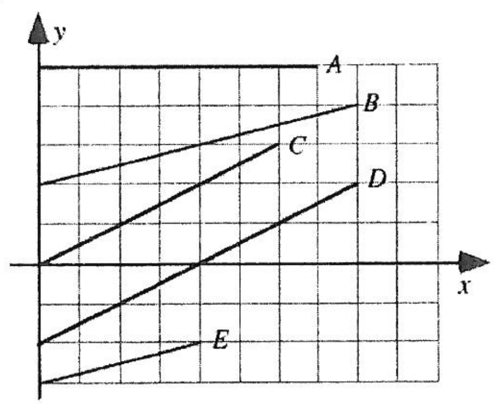


Rank the magnitudes (sizes) of the slopes of the line at the labeled points.

1 Greatest	2	3	4 Least	OR	All the same	All zero	Cannot determine

Explain your reasoning.

Shown are several lines on a graph.

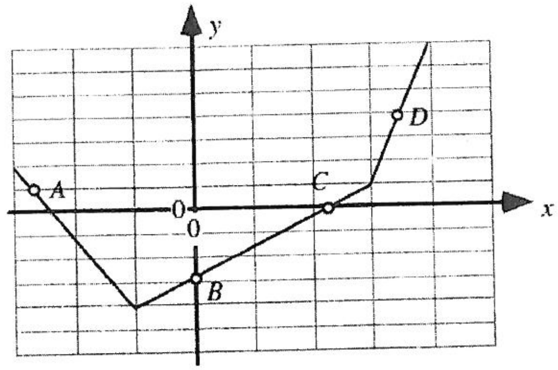


Rank the slopes of the lines in this graph.

1 Greatest	2	3	4	5 Least	OR	All the same	All zero	Cannot determine

Explain your reasoning.

Four points are labeled on a graph.



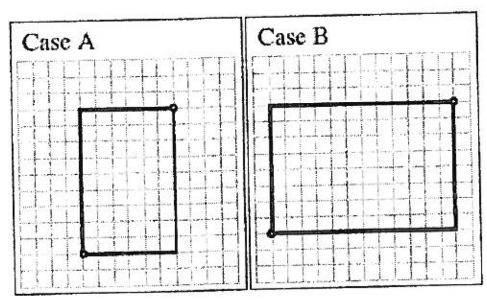
Rank the magnitudes (sizes) of the slopes of the graph at the labeled points.

1 Greatest	2	3	4 Least	OR	All the same	All zero	Cannot determine

Explain your reasoning.

In each case, a rectangle is drawn on a grid. A student makes the following statement in comparing the slopes of the diagonal lines connecting the corners marked by dots:

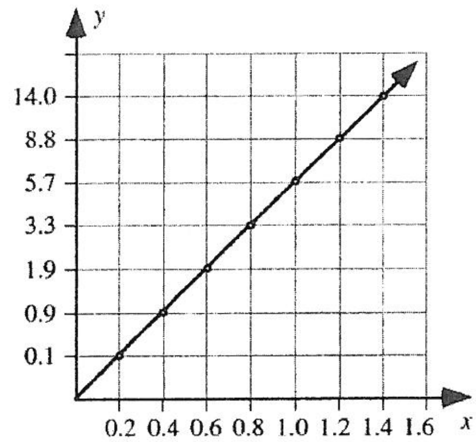
> "The steepness of a line depends on how much the line rises compared to its run. For Case A the rise is 9, and the run is 6, and the difference between rise and run is 3. For Case B, the rise is 8 and the run is 12 and the difference is minus 4. Case B has a smaller slope than Case A, and in Case B the slope is negative."



What, if anything, is wrong with this student's statement? If something is wrong, identify and explain how to correct all errors. If this statement is correct, explain why.

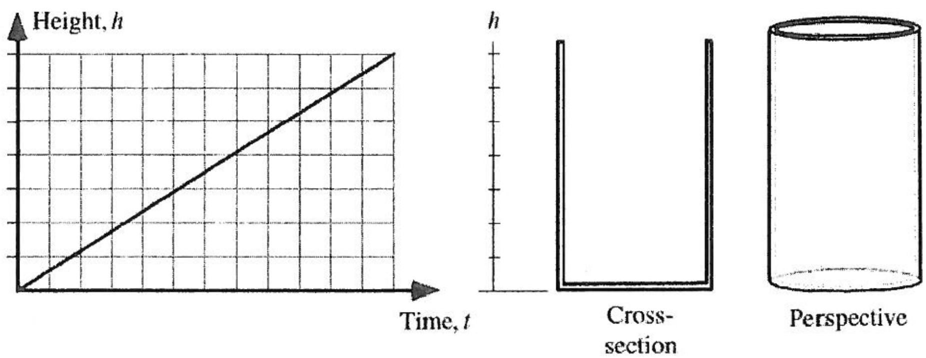
A student uses data from a table to make a graph as shown.

x	y
0.2	0.1
0.4	0.9
0.6	1.9
0.8	3.3
1.0	5.7
1.2	8.8
1.4	14.0



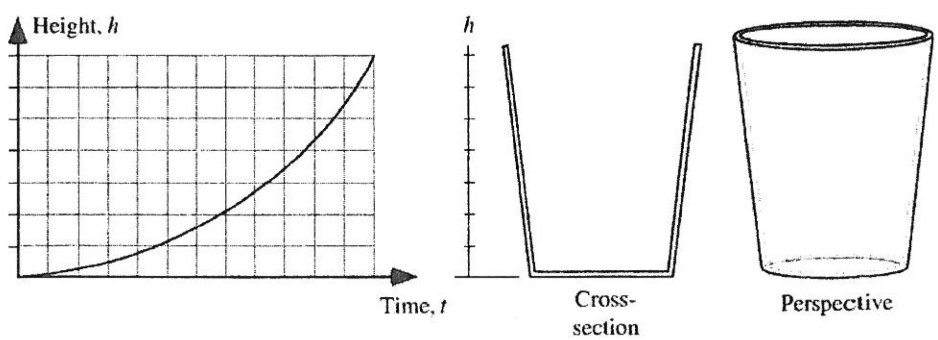
What, if anything, is wrong with this graph? If something is wrong, identify and explain how to correct all errors. If this statement is correct, explain why.

A cylindrical glass is filled using a tap with a constant flow rate of 4 ml per second. A student graphs the height of the water in the glass as a function of time as shown:



What, if anything, is wrong with this graph? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A glass is tapered so that it is wider at the top than at the bottom. The glass is filled using a tap with a constant flow rate of 4 ml per second. A student graphs the height of the water in the glass as a function of time as shown:

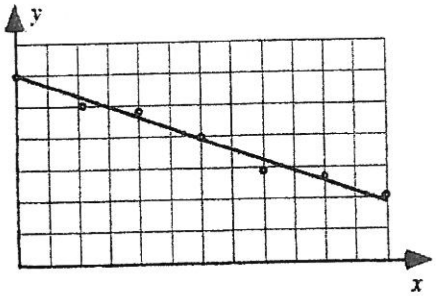


What, if anything, is wrong with this graph? If something is wrong, identify and explain how to correct all errors. If this is correct, explain why.

A student makes the following claim about some data that he and his lab partners have collected:

"Our data show that the value of y decreases as x increases. We found that y is inversely proportional to x."

What, if anything, is wrong with this statement? If something is wrong, identify and explain how to correct all errors. If this statement is correct, explain why.



A. $y = 2x$

B. $y = 3x$

C. $y = 2x + 7$

D. $y = -4x$

E. $y = x^2$

Which, if any, of these equations is consistent with the statement "*If* x *doubles, then* y *also doubles?*"

Explain your reasoning.

Name: ____________

"Pie"

The early Greek geometers worked long and hard to determine the relationship between circumference of a circle and its diameter. Collect data for at least 5 cylindrical objects and record it in the chart below.

1. Graphically and mathematically determine the relationship between circumference and diameter. Sketch the graphical model here, including title, labels, units, and the best-fit line.

Circumference (cm)	Diameter (cm)

2. Write the mathematical model here by substituting the labels, slope, and intercept into the general model. Include units.

$y = mx + b$

3. What is the significance of the slope of the line?

4. What should be the value of the y-intercept? Explain.

5. What would be the diameter of a circle that has a circumference of 18 cm?

AP® PHYSICS 1 EQUATIONS

MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$v_x^2 = v_{x0}^2 + 2a_x (x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$|\vec{F}_f| \le \mu |\vec{F}_n|$

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

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

$\Delta\vec{p} = \vec{F}\,\Delta t$

$K = \frac{1}{2} m v^2$

$\Delta E = W = F_{\parallel} d = F d \cos\theta$

$P = \frac{\Delta E}{\Delta t}$

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

$\omega = \omega_0 + \alpha t$

$x = A\cos(2\pi f t)$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$\tau = r_{\perp} F = r F \sin\theta$

$L = I\omega$

$\Delta L = \tau\,\Delta t$

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

$|\vec{F}_s| = k|\vec{x}|$

$U_s = \frac{1}{2} k x^2$

$\rho = \frac{m}{V}$

a = acceleration
A = amplitude
d = distance
E = energy
f = frequency
F = force
I = rotational inertia
K = kinetic energy
k = spring constant
L = angular momentum
ℓ = length
m = mass
P = power
p = momentum
r = radius or separation
T = period
t = time
U = potential energy
V = volume
v = speed
W = work done on a system
x = position
y = height
α = angular acceleration
μ = coefficient of friction
θ = angle
ρ = density
τ = torque
ω = angular speed

$\Delta U_g = m g \Delta y$

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

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

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

$|\vec{F}_g| = G\frac{m_1 m_2}{r^2}$

$\vec{g} = \frac{\vec{F}_g}{m}$

$U_G = -\frac{G m_1 m_2}{r}$

ELECTRICITY

$|\vec{F}_E| = k\left|\frac{q_1 q_2}{r^2}\right|$

$I = \frac{\Delta q}{\Delta t}$

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

$I = \frac{\Delta V}{R}$

$P = I\,\Delta V$

$R_s = \sum_i R_i$

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

A = area
F = force
I = current
ℓ = length
P = power
q = charge
R = resistance
r = separation
t = time
V = electric potential
ρ = resistivity

WAVES

$\lambda = \frac{v}{f}$

f = frequency
v = speed
λ = wavelength

GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

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

Circle
$A = \pi r^2$
$C = 2\pi r$

Rectangular solid
$V = \ell w h$

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

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

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

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