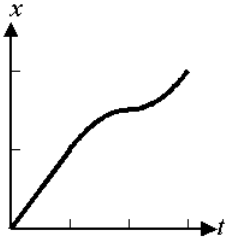
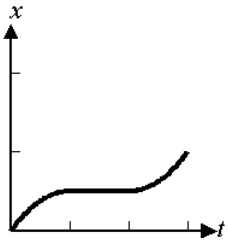
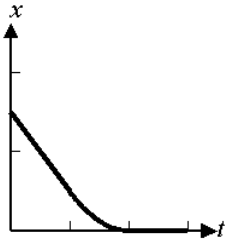
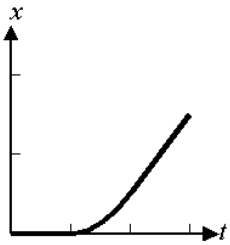
Pre-Assessment Questions

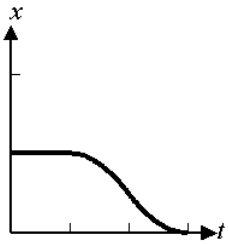
The left column shows six position graphs labeled 1 through 6. The middle column shows six velocity graphs labeled A through F. The right column shows only three acceleration graphs. Two position and two velocity graphs match each acceleration graph. Match each position graph to its corresponding velocity graph, and place that pair (number and letter) in one of the blanks under the corresponding acceleration graph. An example done for you: Position graph 4 matches velocity graph C which matches the top acceleration graph.

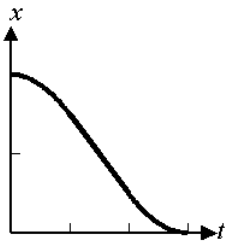
(1) 

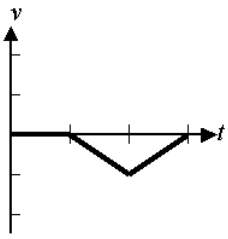
(2) 

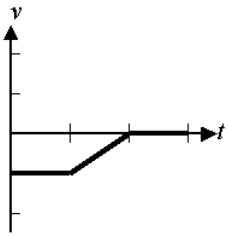
(3) 

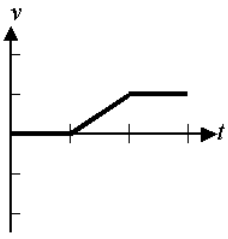
(4) 

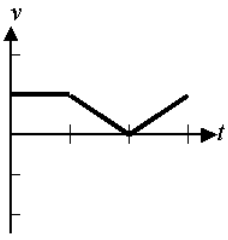
(5) 

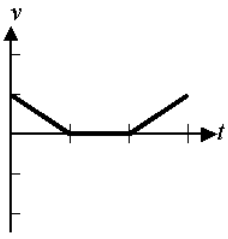
(6) 

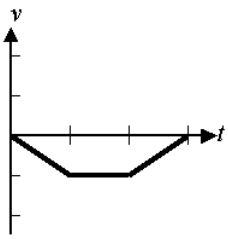
(A) 

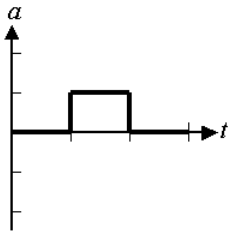
(B) 

(C) 

(D) 

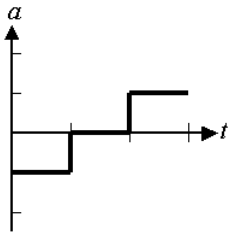
(E) 

(F) 



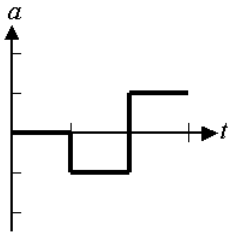
Position: __4__ Velocity: __C__

Position: _____ Velocity: _____



Position: _____ Velocity: _____

Position: _____ Velocity: _____



Position: _____ Velocity: _____

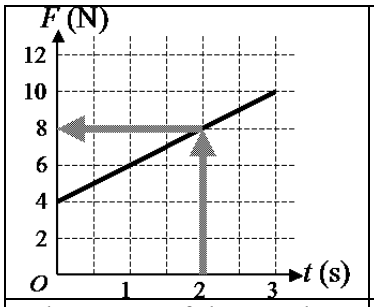
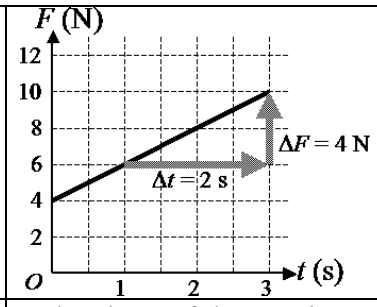
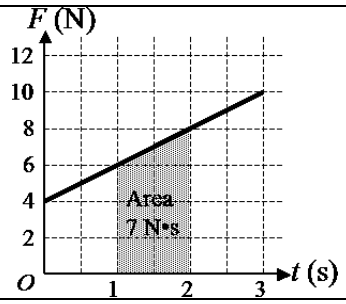
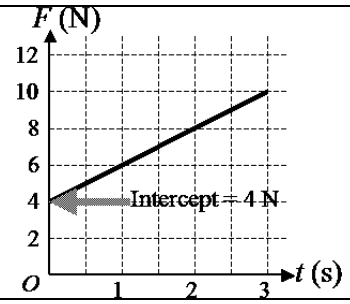
Position: _____ Velocity: _____

When presented with a graph of some sort in AP Physics, always do the following:

- **Check the WORDS on both the axes**. Words like "velocity", "distance", "force", "time", etc. matter and affect the right answer. Any of the words that appear on the AP Physics Table of Equations can appear on the axes of a graph.
- **Choose an EQUATION that relates both of the axes together**. For example, suppose that you have a graph with "force" on the vertical axis and "time" on the horizontal axis. Look at the equation chart to see if you can find an equation that has force and time in it. The equation $\Delta p = F \cdot \Delta t$ has both force and time in it, and can help you answer the question correctly even if you have no idea what to do.

Once you have an equation that relates the two axes quantities together, you can determine whether you should look at the **value**, **slope**, **area**, or **intercept** of the graph to get the right answer.

- **VALUE** is simply looking at the "height" of a point on the graph.
- **SLOPE** is looking at the "steepness" of the graph.
- **AREA** is looking specifically at the area enclosed between the graph curve itself, the horizontal axis, and two vertical lines that must be specified by the situation. *Note: Whenever you take an area, it represents the amount that a quantity has changed, not the final value of a quantity.*
- **INTERCEPT** is the "starting" value on either the horizontal or vertical axis.

			
The **value** of the graph at $t = 2$ s is 8 N. The value of a graph always has the same units as the units indicated on the vertical axis.	The slope of the graph at $t = 2$ s is 2 N/s. The slope of a graph always has units that are the vertical units divided by the horizontal units.	The area of the graph between times $t = 1$ s and $t = 2$ s is 7 N•s. The units of the area is the product of the units on the two axes.	This graph has a vertical intercept of 4 N. The units of the intercept are the same as the units of the axis that the graph intercepts.

HOW DO I KNOW WHEN TO LOOK AT VALUE, SLOPE, OR AREA?

It is often not difficult to know when to look at the value of a graph. For the above example graph, the question would just ask for the force at time $t = 2$ seconds. Because "force" is the vertical-axis quantity and you are given a specific point on the horizontal axis (a time), you would just look up from $t = 2$ seconds and over to find a force of 8 N. This is considered very low-level and would almost certainly not appear on an AP exam.

A question that is more likely to appear is: What is the object's change in momentum between $t = 1$ s and $t = 2$ s? Students often know that they need to find either the area or the slope of the graph, but don't know which one it is.

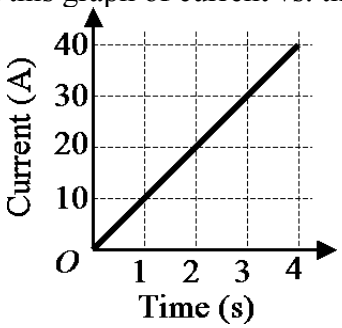
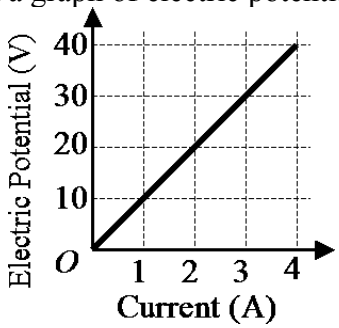
Super Hint: "Area" always has to be taken between two points on the horizontal axis, so if the problem says "from (a time or place) to (a time or place)" or "between (a time or place) and (another time or

place), then it is likely that you'll have an area to calculate. If the problem only references ONE time or place, then you may only need to take the slope, since slope can be evaluated at a single point.

That "super-hint" is not enough to help you answer all questions about graphs, so here's a sure-fire method to determining whether to take the slope or whether to take the area. It piggybacks off of the "things you should do when you see a graph" at the top of the previous page.

- Step 1: Find an equation on the equation chart that has both quantities in it that appear on the graph axes.
- Step 2: Rearrange the equation so that both of the axes-quantities are on the same side together.
- Step 3: If the two axes-quantities divide (rise over run), then take the slope. If the two axes-quantities multiply (base times height), then take the area.

Examples:

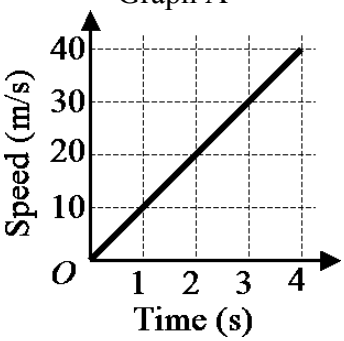
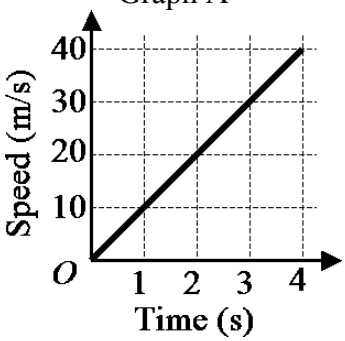
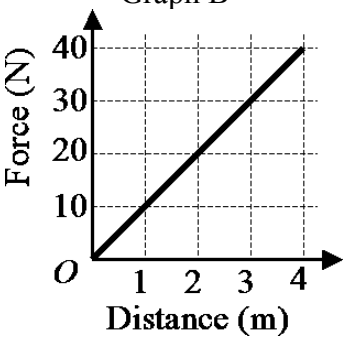
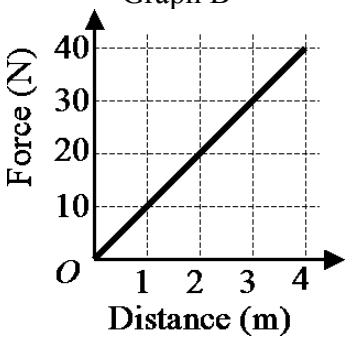
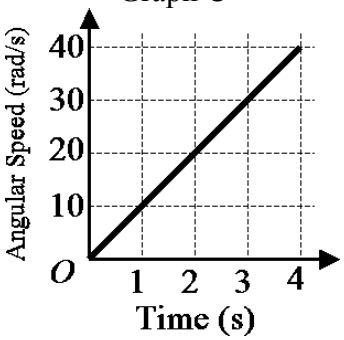
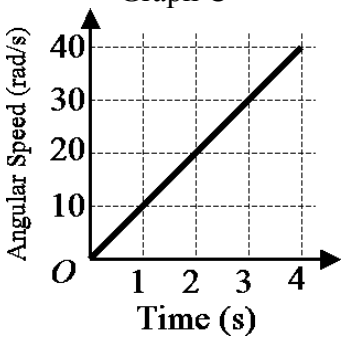
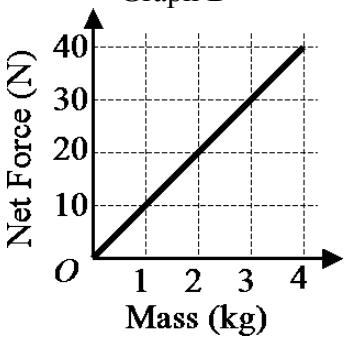
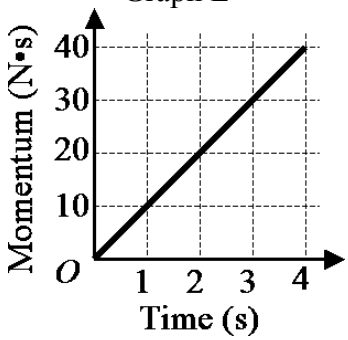
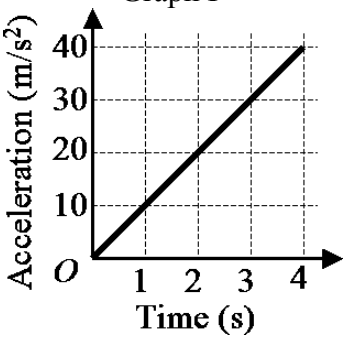
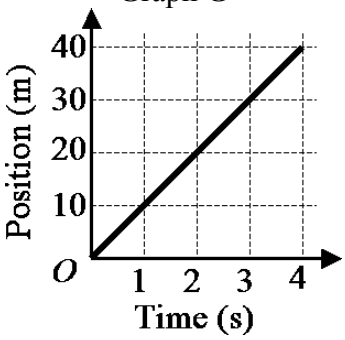
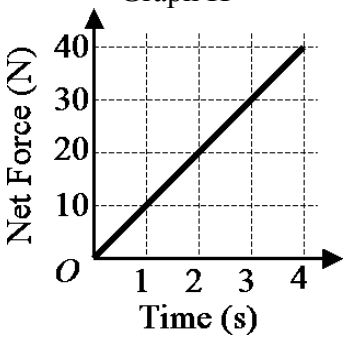
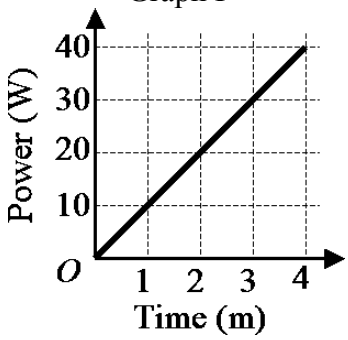
You are given this graph of current vs. time.  Is it the area or is it the slope that means something? Find an equation with "current" and "time" in it. Under "Electricity", you find this equation with current (I) and time (t) in it: $I = \frac{\Delta q}{\Delta t}$ (where q is charge). Rearrange to get current and time on the same side (because those are the two quantities in the graph) $\Delta q = I \Delta t$ Current and time multiply, so take the area to get charge	You are given a graph of electric potential vs. current.  Is it the area or is it the slope that means something? Find an equation with "electric potential" and "current" in it. Under "Electricity", you find this equation with electric potential (V) and current (I) in it: $I = \frac{\Delta V}{R}$ (where R is resistance). Rearrange to get electric potential and current on the same side (because those are the two quantities in the graph) $R = \frac{\Delta V}{I}$ Potential difference is on top (the "rise") and current is on the bottom ("run"), so the slope of the graph is resistance.

NOTE: What if you are given a graph of velocity vs. time? There are two equations with velocity and time in them: $x = x_0 + v_0 t + \frac{1}{2} a t^2$ and $v = v_0 + at$. You are allowed to disregard all but one term on the right hand side. If the graph is a line, disregard terms that are constant and terms that have powers. This means that:

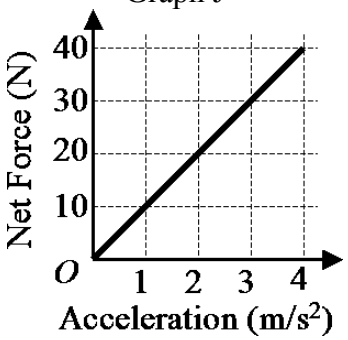
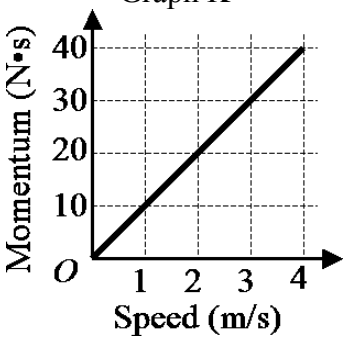
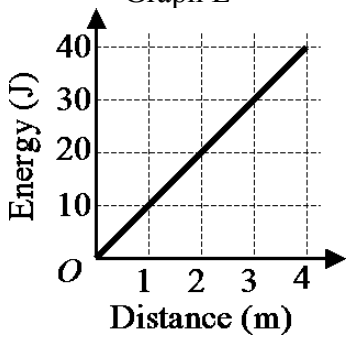
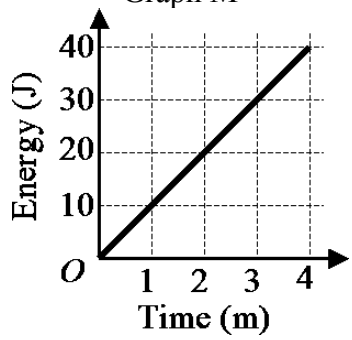
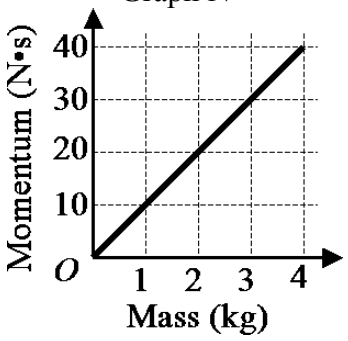
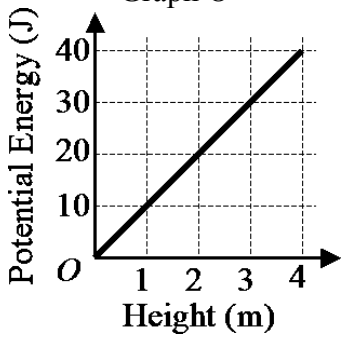
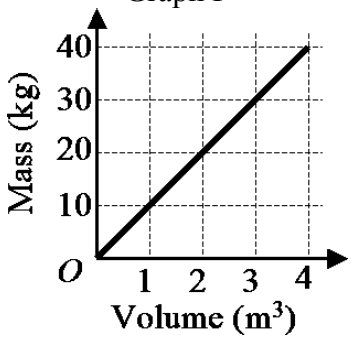
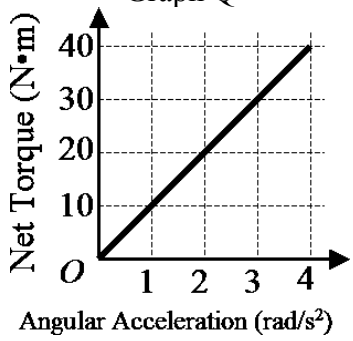
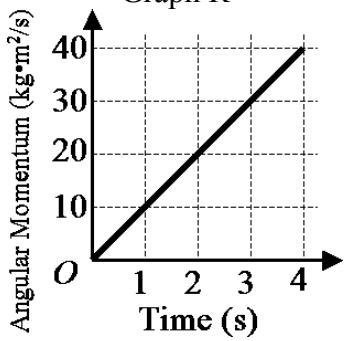
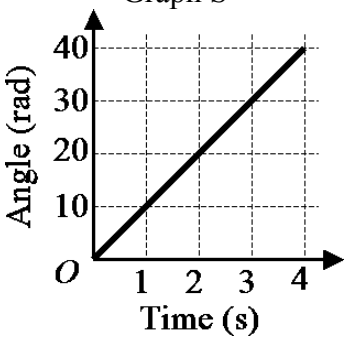
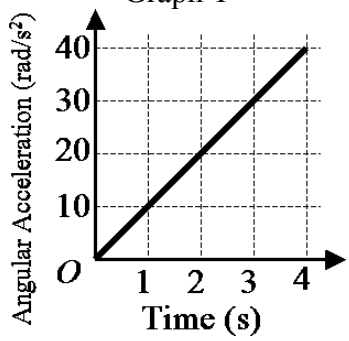
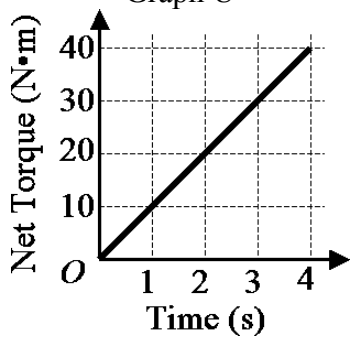
- $x = x_0 + v_0 t + \frac{1}{2} a t^2$ becomes $x = vt$, so displacement is the area of a velocity vs. time graph and velocity is the slope of a displacement vs. time graph.

- $v = v_0 + at$ becomes $v = at$, so change in velocity is the area of an acceleration vs. time graph and acceleration is the slope of a velocity vs. time graph.

Directions: Match each graph A–U with one of the descriptions 1–19 listed on the next page. Also, for each graph, write a basic equation that justifies your match. Graphs A, B, and C match two descriptions and therefore appear twice. Descriptions (1) through (5) are used twice. *Hint: All equations for this activity appear under "Mechanics" on the AP Physics Table of Equations.*

Graph A  Description: _____ Equation:	Graph A  Description: _____ Equation:	Graph B  Description: _____ Equation:	Graph B  Description: _____ Equation:
Graph C  Description: _____ Equation:	Graph C  Description: _____ Equation:	Graph D  Description: _____ Equation:	Graph E  Description: _____ Equation:
Graph F 	Graph G 	Graph H 	Graph I 

Description: _____ Equation:	Description: _____ Equation:	Description: _____ Equation:	Description: _____ Equation:

Graph J  Description: _____ Equation:	Graph K  Description: _____ Equation:	Graph L  Description: _____ Equation:	Graph M  Description: _____ Equation:
Graph N  Description: _____ Equation:	Graph O  Description: _____ Equation:	Graph P  Description: _____ Equation:	Graph Q  Description: _____ Equation:
Graph R  Description: _____ Equation:	Graph S  Description: _____ Equation:	Graph T  Description: _____ Equation:	Graph U  Description: _____ Equation:

Descriptions:

(1)(1) I have a mass of 10 kg	(8) I sped up by 80 m/s	(15) I gained 80 rad/s of rotational speed
(2)(2) I am moving at a speed of 10 m/s	(9) My weight is 10 N	(16) My angular acceleration is 10 rad/s^2
(3)(3) I have an acceleration of 10 m/s^2	(10) I gained 80 N•s of momentum	(17) My rotational inertia is 10 $kg•m^2$
(4)(4) The net force on me is 10 N	(11) The power delivered to me is 10 W	(18) The net torque on me is 10 N•m
(5)(5) I gained 80 J of energy	(12) I have a spring constant of 10 N/m	(19) I gained 80 $kg•m^2/s$ of angular momentum
(6) My density is 10 kg/m^3	(13) I rotated through an angle of 80 rad	
(7) I traveled a distance of 80 m	(14) My angular speed is 10 rad/s	

ADVANCED PLACEMENT PHYSICS 1 EQUATIONS, EFFECTIVE 2015

MECHANICS

$v_x = v_{x0} + a_x t$

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

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

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

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

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

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

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

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

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

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

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

$\omega = \omega_0 + \alpha t$

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

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

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

$L = I\omega$

$\Delta L = \tau \Delta t$

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

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

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

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

a = acceleration
d = distance
E = energy
f = frequency
F = force
h = height
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
α = angular acceleration
μ = coefficient of friction
θ = angle
ρ = density
τ = torque
ω = angular speed

$\Delta U_g = mg \Delta y$

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

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

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

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

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

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

ELECTRICITY

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

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

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

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

$P = I \Delta V$

$R_s = \sum_i R_i$

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

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
$c^2 = a^2 + b^2$
$\sin\theta = \frac{a}{c}$
$\cos\theta = \frac{b}{c}$
$\tan\theta = \frac{a}{b}$