AP Physics 1 — Summer Assignment

Welcome to AP Physics 1!

I'm excited for next school year and for the privilege of teaching you physics next year. I hope you're excited for the opportunity to work hard and to learn physics at a college level.

Physics is awesome. It is a field of study that spans everything from the smallest particles we know to exist (quarks and leptons, quantum mechanics) to the universe itself (relativity, black holes, galaxies). AP Physics 1 exists in the middle of those extremes, analyzing objects we can see and interact with on an everyday basis. Topics include linear motion, forces, energy, power, momentum, torque and rotation, oscillations, and fluids.

Physics is also a field that involves a lot of problem solving. Each problem is its own puzzle to solve. You have to know physics but also have the mathematical and reasoning tools required to approach the problems logically. Which takes us to...

The Purpose of our AP Physics 1 Summer Assignment

Look at the sample AP Physics 1 multiple choice questions on the back of this page. What stands out to you about these questions?

You may notice that most answer choices have multiple variables in the answers instead of just numerical answers (Calculators won't help with most of these problems). You may also notice some trig functions in one question, and explanations needed in another question. You certainly noticed that these questions look significantly more complex than questions in previous science tests you've taken.

So, this summer assignment gets into some of the math and reasoning skills that we'll use throughout the year, including unit conversions, manipulating algebraic equations, proportional reasoning, and basic right triangle trigonometry. That way, when we start learning actual physics in August, you'll be ready with the basic skills you need to dive into some challenging problems.

The AP Physics 1 Exam

All students enrolled in AP Physics 1 are required to take the exam, which is comprised of two sections:

Multiple Choice	40 questions	80 minutes
Free Response	4 questions	100 minutes

There are four AP Physics classes that College Board offers: AP Physics 1 & 2, C: Mechanics, and C: Electricity and Magnetism. AP Physics 1 & 2 are algebra-based, and the AP Physics C classes are calculus-based. AP Physics 1 is meant to be an introductory physics class.

Logistics of this AP Physics Summer Assignment

There are five lessons in this assignment. The entire assignment is due on the first day of classes, which is Monday, August 10th at the start of the school day. No late work will be accepted. For each lesson, you will watch a video (linked on the digital version of this doc -except for the last one), take notes on it, then complete the practice problems. There will be a test on these concepts in the first week of class.

The practice problems for each lesson include problems from that lesson, as well as review from the previous sections. The problems are mixed intentionally because research on learning shows that doing mixed practice helps us retain skills for longer than doing the same problem type repeatedly does.

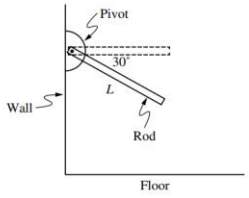
I recommend not doing all the work right at the beginning of the summer. It's best if you spread it out, rather than having the full two-month break between this work and the start of the school year.

Finally, get help early if you need it in any section of this work! I'm available throughout the summer to respond to messages or even do group tutoring if needed. Please just let me know.

If you have any questions at all, please email me at michele.vocu@bvhs.org.

Have a great summer!
-Mrs. Vocu

Sample AP Physics 1 exam questions:



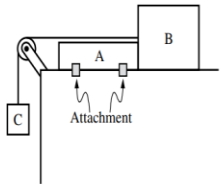
A uniform rod of mass M_0 and length L is free to rotate about a pivot at its left end and is released from rest when the rod is 30° below the horizontal, as shown in the figure. With respect to the pivot, the rod has rotational inertia $I_0 = \frac{1}{3}M_0L^2$. Which of the following expressions correctly represents the magnitude of the net torque exerted on the rod about the pivot at the moment the rod is released?

(A) $M_0g\left(\frac{L}{2}\right)\sin(30°)$

(B) $M_0g\left(\frac{L}{2}\right)\sin(60°)$

(C) $M_0gL\sin(30°)$

(D) $M_0gL\sin(60°)$



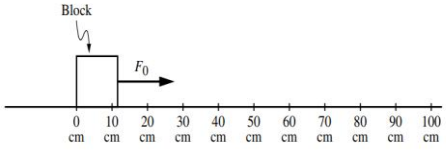
Blocks A and B, of masses m_A and m_B, respectively, are at rest on a horizontal surface with negligible friction. Block A is attached to the table. Block C of mass m_C is suspended by a string that is tied to Block B and passes over a pulley as shown. The blocks all remain at rest. Which of the following gives the magnitude of the force exerted by Block A on Block B?

(A) m_Bg

(B) m_Cg

(C) $\frac{m_Am_Cg}{m_A+m_B}$

(D) $\frac{m_Bm_Cg}{m_A+m_B}$



A constant force F_0 is exerted continuously on a block that is initially at rest on a horizontal surface. The change in kinetic energy of the block while the block is moved from position $x = 0$ to $x = 50$ cm is ΔK_1, and the change in kinetic energy of the block as the block is moved from $x = 50$ cm to $x = 100$ cm is ΔK_2. How does ΔK_1 compare to ΔK_2, and why?

(A) $\Delta K_2 = \Delta K_1$ because the velocity increases by the same amount between 0 cm to 50 cm and between 50 cm to 100 cm.

(B) $\Delta K_2 = \Delta K_1$ because the applied force does the same work on the block between 0 cm to 50 cm and between 50 cm to 100 cm.

(C) $\Delta K_2 > \Delta K_1$ because the block is moving faster on average between 50 cm to 100 cm than it is between 0 cm to 50 cm.

(D) $\Delta K_2 > \Delta K_1$ because the rate of change of kinetic energy is greater between 50 cm to 100 cm than it is between 0 cm to 50 cm.

Here is the equation sheet for AP Physics 1. You'll get a copy of this on the AP exam, and you are welcome to use it on all assignments and assessments in the class. A calculator is allowed on both sections of the exam as well.

ADVANCED PLACEMENT PHYSICS 1 TABLE OF INFORMATION

CONSTANTS AND CONVERSION FACTORS	
Universal gravitational constant, $G = 6.67\times10^{-11}\ \text{m}^3/(\text{kg}\cdot\text{s}^2) = 6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$ 1 atmosphere of pressure, $1\ \text{atm} = 1.0\times10^5\ \text{N}/\text{m}^2 = 1.0\times10^5\ \text{Pa}$	Acceleration due to gravity at Earth's surface, $g = 9.8\ \text{m}/\text{s}^2$ Magnitude of the gravitational field strength at the Earth's surface, $g = 9.8\ \text{N}/\text{kg}$

PREFIXES		
Factor	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

UNIT SYMBOLS				
	hertz,	Hz	newton,	N
	joule,	J	pascal,	Pa
	kilogram,	kg	second,	s
	meter,	m	watt,	W

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES							
θ	0°	30°	37°	45°	53°	60°	90°
$\sin\theta$	0	1/2	3/5	$\sqrt{2}/2$	4/5	$\sqrt{3}/2$	1
$\cos\theta$	1	$\sqrt{3}/2$	4/5	$\sqrt{2}/2$	3/5	1/2	0
$\tan\theta$	0	$\sqrt{3}/3$	3/4	1	4/3	$\sqrt{3}$	∞

The following conventions are used in this exam:

- The frame of reference of any problem is assumed to be inertial unless otherwise stated.
- Air resistance is assumed to be negligible unless otherwise stated.
- Springs and strings are assumed to be ideal unless otherwise stated.
- Fluids are assumed to be ideal, and pipes are assumed to be completely filled by fluid, unless otherwise stated.

GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

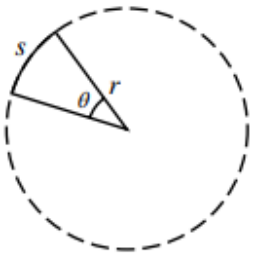
Triangle
$A = \frac{1}{2}bh$

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

Rectangular Solid
$V = \ell wh$

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

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$



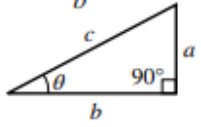
A = area
b = base
C = circumference
h = height
ℓ = length
r = radius
s = arc length
S = surface area
V = volume
w = width
θ = angle

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

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

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

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



MECHANICS AND FLUIDS

$v_x = v_{x0} + a_x t$

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

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

$\vec{x}_{\text{cm}} = \frac{\sum m_i \vec{x}_i}{\sum m_i}$

$\vec{a}_{\text{sys}} = \frac{\sum \vec{F}}{m_{\text{sys}}} = \frac{\vec{F}_{\text{net}}}{m_{\text{sys}}}$

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

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

$\vec{F}_s = -k\Delta\vec{x}$

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

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

$W = F_{\parallel} d = Fd\cos\theta$

$\Delta K = \sum W_i = \sum F_{\parallel,i} d_i$

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

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

$\Delta U_g = mg\Delta y$

$P_{\text{avg}} = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}$

$P_{\text{inst}} = F_{\parallel} v = Fv\cos\theta$

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

$\vec{F}_{\text{net}} = \frac{\Delta\vec{p}}{\Delta t} = m\frac{\Delta\vec{v}}{\Delta t} = m\vec{a}$

$\vec{J} = \vec{F}_{\text{avg}} \Delta t = \Delta\vec{p}$

$\vec{v}_{\text{cm}} = \frac{\sum \vec{p}_i}{\sum m_i} = \frac{\sum (m_i \vec{v}_i)}{\sum m_i}$

a = acceleration
d = distance
E = energy
F = force
J = impulse
k = spring constant
K = kinetic energy
m = mass
p = momentum
P = power
r = radius, distance, or position
t = time
U = potential energy
v = velocity or speed
W = work
x = position
y = height
θ = angle
μ = coefficient of friction

$\omega = \omega_0 + \alpha t$

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

$\omega^2 = \omega_0^2 + 2\alpha\left(\theta - \theta_0\right)$

$v = r\omega$

$a_T = r\alpha$

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

$I = \sum m_i r_i^2$

$I' = I_{\text{cm}} + Md^2$

$\alpha_{\text{sys}} = \frac{\Sigma\tau}{I_{\text{sys}}} = \frac{\tau_{\text{net}}}{I_{\text{sys}}}$

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

$W = \tau\Delta\theta$

$L = I\omega$

$L = rmv\sin\theta$

$\Delta L = \tau\Delta t$

$\Delta x_{\text{cm}} = r\Delta\theta$

$T = \frac{1}{f}$

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

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

$x = A\cos(2\pi ft)$

$x = A\sin(2\pi ft)$

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

$P = \frac{F_{\perp}}{A}$

$P = P_0 + \rho gh$

$P_{\text{gauge}} = \rho gh$

$F_b = \rho V g$

$A_1 v_1 = A_2 v_2$

$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

a = acceleration
A = amplitude or area
d = distance
f = frequency
F = force
h = height
I = rotational inertia
k = spring constant
K = kinetic energy
ℓ = length
L = angular momentum
m = mass
M = mass
P = pressure
r = radius, distance, or position
t = time
T = period
v = velocity or speed
V = volume
W = work
x = position
y = vertical position
α = angular acceleration
θ = angle
ρ = density
τ = torque
ω = angular speed

Lesson 1 — Metric Unit Conversions

Use this page to take notes on this video: Converting Metric Units - Multiplying by a conversion factor

This table is provided on the AP Physics 1 Equations Sheet:

PREFIXES		
Factor	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Simple metric unit conversion

1) 52.3 g = _____ kg

Unit conversion of a unit in the denominator

2) 15 N/cm = _____ N/m

Unit conversion of units in numerator and denominator

3) 0.045 kN/cg = _____ N/g

Lesson 1 Practice Problems

(You may complete the first 10 – do more if you need the practice)

1) 5.7 N = _____ kN

2) .0068 mm = _____ m

3) 9035 cL = _____ L

4) 55.1 N/mm = _____ N/m

5) 2.17 N/mg = _____ kN/cg

6) 193 kN = _____ N

7) 680 g = _____ cg

8) 409.1 mL = _____ L

9) 17.5 N/m = _____ N/mm

10) 380 kN/g = _____ N/cg

11) 1,754,000 ps = _____ s

12) 47.2 µL = _____ dL

13) 4,000 Gb = _____ Tb

14) 21 mg/dL = _____ mg/L

15) 0.00513 µs = _____ ns

16) 1.25 J = _____ kJ

17) 3.5 min = _____ s

18) 0.15 km/min = _____ m/s

19) 472.2 nm = _____ m

20) 801 MJ = _____ J

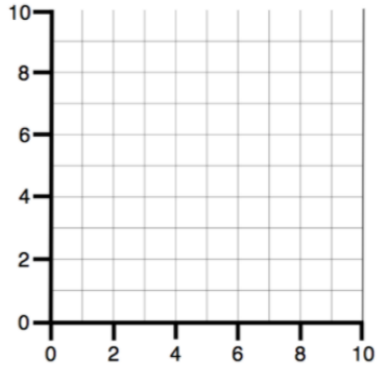
Lesson 2 — Function Types & Proportional Reasoning

Use this page to take notes on this video: [Proportional Relationships and Reasoning in Physics]

Linear

$y \propto$ $y =$

x	y
0	
1	
2	
3	
4	



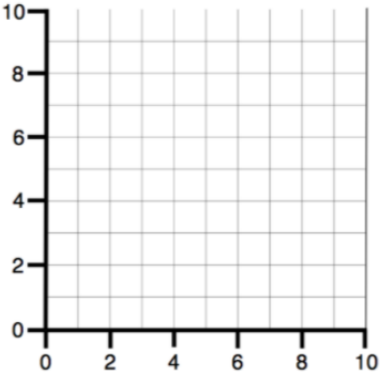
If ***x*** doubles, ***y***

If ***x*** triples, ***y***

Quadratic

$y \propto$ $y =$

x	y
0	
1	
2	
3	
4	



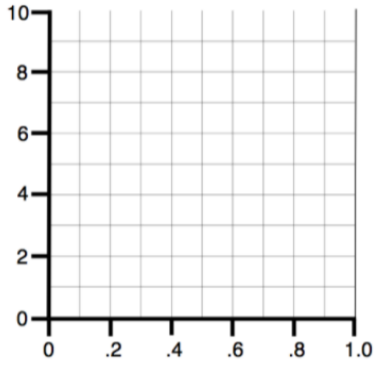
If ***x*** doubles, ***y***

If ***x*** triples, ***y***

Inverse

$y \propto$ $y =$

x	y
0	
.1	
.2	
.3	
.4	



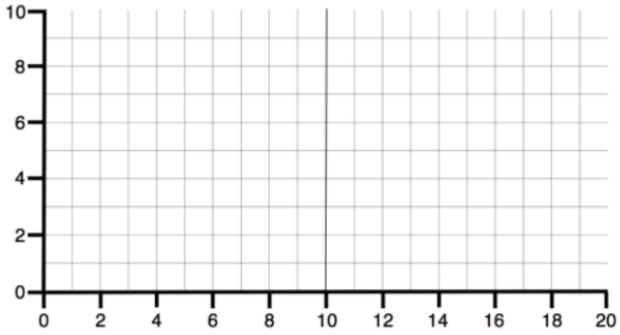
If ***x*** doubles, ***y***

If ***x*** triples, ***y***

Square Root

$y \propto$ $y =$

x	y
0	
1	
2	
3	
4	
9	
16	



If ***x*** doubles, ***y***

If ***x*** triples, ***y***

Summarize:

Lesson 2 Practice Problems

Note: All equations in this section are taken from the AP Physics 1 Equations Sheet.

1. Use the equation for kinetic energy (on the right) to answer the questions.

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

   a. *K* and *m* have a _____ relationship.
   b. If you double the value of m, the value of *K* _____.
   c. *K* and *v* have a _____ relationship.
   d. If you double the value of v, the value of *K* _____.
   e. Sketch a graph that shows the function relationship between *K* and *v*. Label the axes!



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

r is doubled. What happens to a_c?

v is doubled. What happens to a_c?

What kind of relationship do a_c *and* *v* have?

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

V is doubled. What happens to ρ?

V is halved. What happens to ρ?

m is doubled. What happens to ρ?

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

r is doubled. What happens to F_g?

G is doubled. What happens to F_g?

m_1 and m_2 are both doubled. What happens to F_g?

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

m is doubled. Does T_s doubled as well? Explain.

m is increased by a factor of 4. What happens to T_s?

k is increased by a factor of 4. What happens to T_s?

6. Convert 32.4 N to other units to complete the equation below:

_____ mN = 32.4 N = _____ kN = _____ MN

7. Complete these conversions:

0.000024 km = _____ mm

98 N/mm = _____ N/m

175 N/cg = _____ kN/g

Lesson 3 — Manipulating Equations

Use this page to take notes on this video: [Manipulating Physics Equations to Solve for a Variable]

Rearranging equations to solve for a variable

1. Solve for ω:

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

2. Solve for θ, in terms of W:

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

3. Solve for r:

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

Solving systems of physics equations for a particular variable

Use the equations below to solve for p in terms of a, x, and m, given that $v_0 = 0$ and $x_0 = 0$.

$$\vec{p} = m\vec{v} \qquad x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2 \qquad v_x = v_{x0} + a_x t$$

Lesson 3 Practice Problems

1. Solve this equation for x. (*You can ignore the subscript x's if you'd like.)*

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

$x =$

2. Solve this equation for v:

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

$v =$

3.

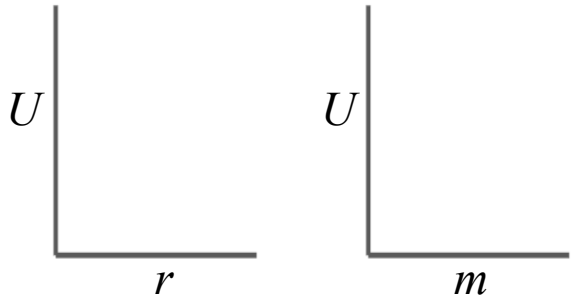
$$T_p = 2\pi\sqrt{\frac{\ell}{g}}$$

To cause T_p to double, by what factor would you need to multiply l?

If you multiplied g by 4, by what factor would T_p decrease by?

4. Sketch graphs to show the relationships between variables.

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



5. Solve this equation for l:

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

6. Solve this equation for f:

$$x = A\cos(2\pi ft)$$

$l =$

$f =$

7. Use the equations below to solve for α in terms of v, r, t, and ω_0:

$$\omega = \omega_0 + \alpha t \qquad v = r\omega$$

8. Use the equations below to solve for a_c in terms of r, m, and K:

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

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

$\alpha =$

$a_c =$

9. Find a ruler or other measuring device. Measure the width of a standard piece of paper, and report it out using the units shown below:

_____ mm = _____ cm = _____ m = _____ km

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10. Use the equations below to solve for F_g in terms of U_G and r. *(You can ignore the absolute value and the negative signs for this problem.)*

$$\left|\vec{F}_g\right| = G\frac{m_1 m_2}{r^2} \qquad U_G = -\frac{Gm_1 m_2}{r}$$

11. Solve this equation for a_x:

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

$F_g =$

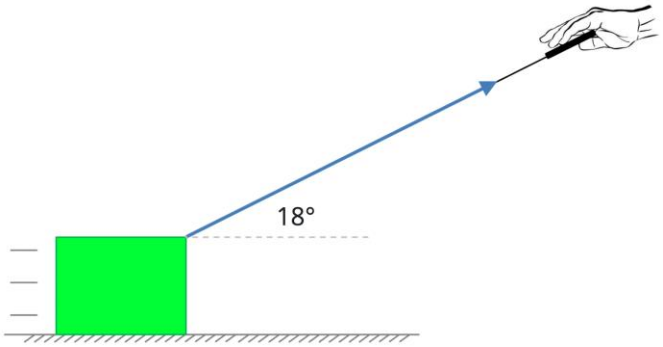
$a_x =$

Lesson 4 — Vector Trigonometry

Use this page to take notes on this video: [Diagonal Vector Trigonometry]

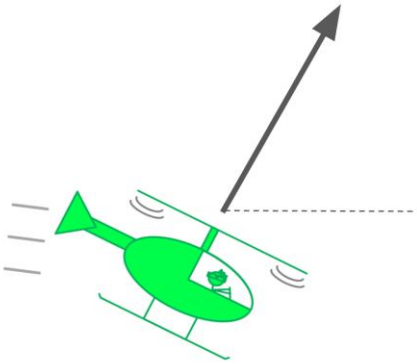
Solving for unknown vectors using trig functions (SOH CAH TOA)

The disembodied hand is pulling a box with a force of 50 N. Calculate the horizontal and vertical components of this force.



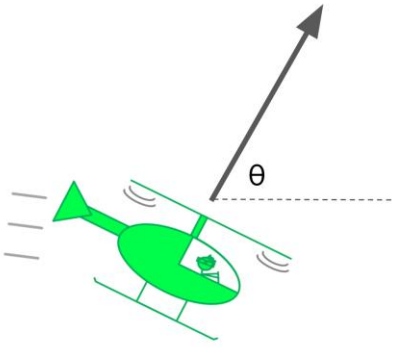
Solve for unknown vectors using Pythagorean Theorem

The thrust force from the helicopter's blades has a horizontal component of 20 kN and a vertical component of 40 kN. What is the magnitude of the thrust force?



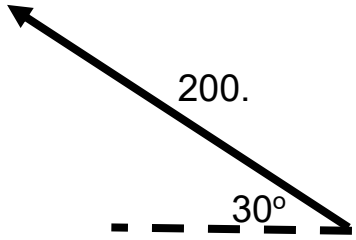
Solve for unknown angle using $\tan^{-1}$

The thrust force from the helicopter's blades has a horizontal component of 20 kN and a vertical component of 40 kN. What is the angle, θ, of the thrust force?

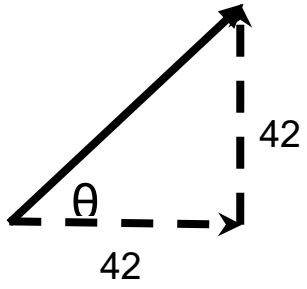


Lesson 4 Practice Problems

1. Calculate the **magnitude** of the horizontal and vertical components of the vector below.

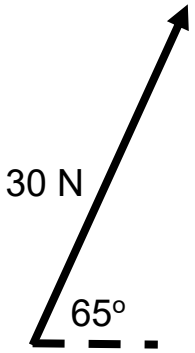


2. Calculate the **magnitude** and **angle** of the force vector, which has a horizontal component of 42 kN and a vertical component of 42 kN.



3. Complete the unit conversions:
   a. 193 kN = _____ N
   b. 680 g = _____ cg
   c. 409.1 mL = _____ L
   d. 17.5 N/m = _____ N/mm
   e. 380 kN/g = _____ N/cg
   f. 5,240,000 cm = _____ km

4. Calculate the **magnitude** of the horizontal and vertical components of this vector.



5. Use the table to determine the type of relationship between kinetic energy and velocity.

V (m/s)	KE (J)
1	4
2	16
3	36
4	64

   a. What kind of variable relationship exists between *V* and *KE*?

   b. If you double *V*, what happens to *KE*?

   c. Sketch a graph of this relationship. (Remember to label both axes!)



6. Calculate the **magnitude** and **angle** of a force vector that has a horizontal component of 75 N and a vertical component of 100 N.

7. The equations for the volume and surface area of a cylinder are given below. Solve for *S* in terms of *V* and *r* (make sure *l* is not in the equation).

$$V = \pi r^2 \ell$$

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

$S =$

8. An 85-meter rope runs from the top of a building to a stake in the ground at a point 45 meters from the base of the building. What angle does the rope make with the ground? How tall is the building?

angle between rope and ground =
height of building =

Linearization Introduction

Name: _____

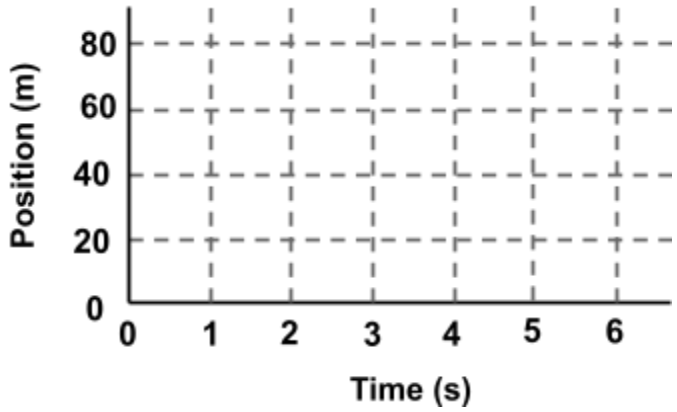
1. A car is traveling in the positive direction with a constant velocity of 12 m/s. At t = 0, the car's location is assumed to be zero. The position of the car at all times past t = 0 can be determined by the following equation, where **x** is the location of the car in meters and **t** is the time in seconds.

$$\mathbf{x = (}12\text{ m/s}\mathbf{)t}$$

   a. Using the equation shown above, fill out the following table.

Time, **t** (s)	0	1	2	3	4	5	6
Location, **x** (m)							

   b. On the graph below, **plot** the car's location as a function of time using the data in the table.



   c. On the graph, **sketch** a linear best-fit that best represents the data.

   d. **Calculate** the slope of your best-fit line.

   e. The slope you calculated should be equal to **12 m/s**. Explain why this is what the slope <u>should</u> be equivalent to. Support your explanation by directly referring to the car's location equation.

   f. If the car had been located at x = 20 m when t = 0…

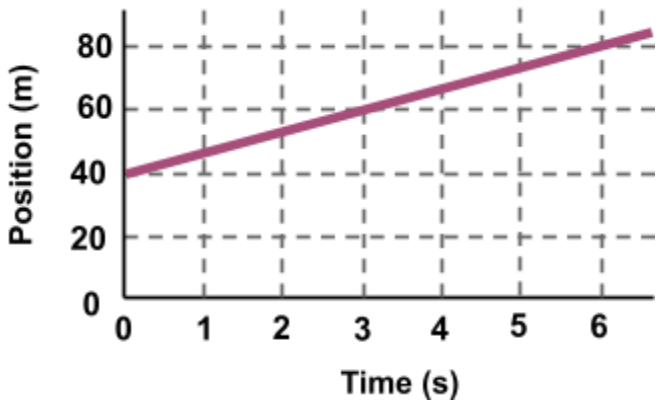
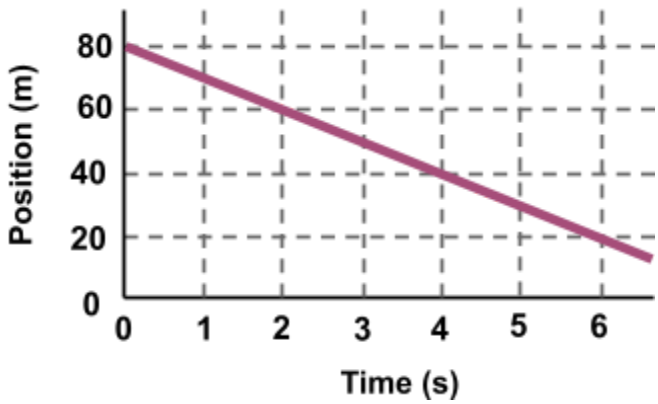
      i. …. how would this change have ultimately affected the best-fit line sketched in part (d)? Briefly discuss.

      ii. …. a student comes up with the equation shown to the right. Does this new equation accurately match the change?

$$\mathbf{x = (}12\text{ m/s}\mathbf{)t - (}20\text{ m}\mathbf{)}$$

      ___ Yes ___ No
      Briefly justify your selection.

2. Car A & car B are both traveling with constant velocities. The graphs below show their positions as a function of time. Complete their location equations based on their graphs.

Car A	Car B
	
x_A = (_____)t + (_____)	x_A = (_____)t + (_____)

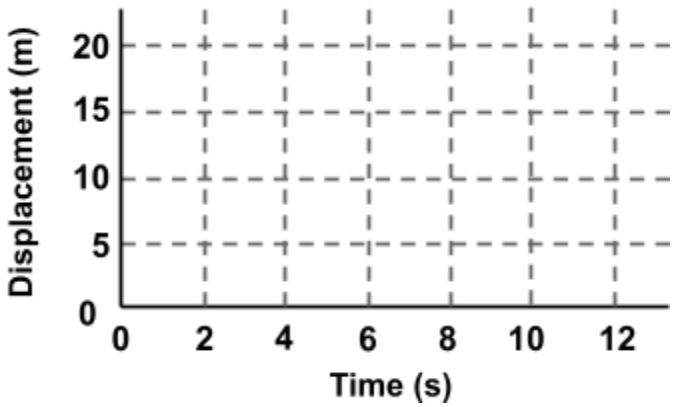
3. A toy car begins at rest. At t = 0, it begins experiencing a constant acceleration of **a**. Its displacement (∆**x**) from its starting position as a function of time can be calculated using the following equation:

$$\Delta x = 0.5at^2$$

   a. A student has a toy car with an acceleration is 0.25 m/s^2. Complete the table below by calculating the displacement of the toy car for each of the following times. The first two have already been completed for you.

Time, **t** (s)	0	2	4	6	8	10	12
Displacement, ∆**x** (m)	0	0.5					

   b. On the graph below, **plot** the car's displacement as a function of the time using the data in the table above.



      i. On the graph, **sketch** a best-fit that best represents the data.

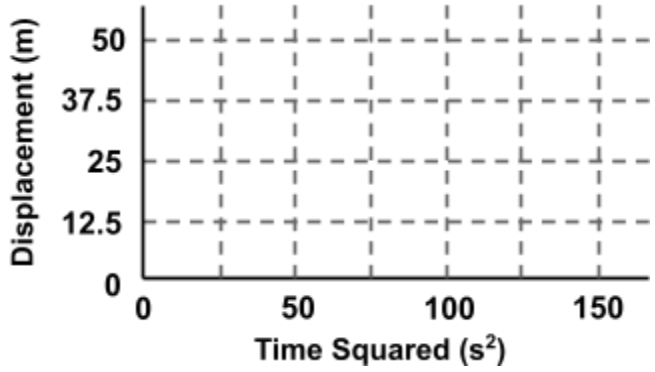
      ii. Which of the following terms best describes the shape of your best-fit line?

      ____ Linear ____ Quadratic ____ Inverse

c. Another student has a toy car with an acceleration of **0.6 m/s²**. This student, however, wishes to plot the car's displacement as a function of time squared. The data table below reflects this. Complete the table below for each value of **t²**.

Time squared, **s²** (s^2)	0	4	16	36	64	100	144
Displacement, **x** (m)	0						

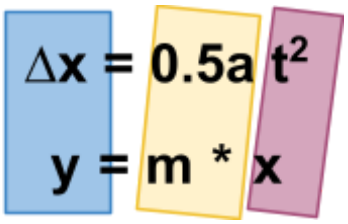
d. On the graph below, **plot** the car's displacement as a function of its time squared using the data in the table above.



i. On the graph, **sketch** a linear best-fit that best represents the data.

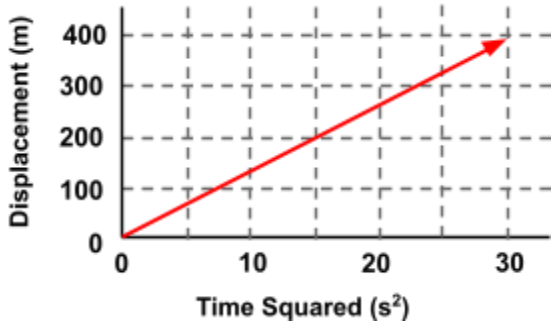
ii. Calculate the slope of your best-fit line.

iii. Consider the diagram to the right. When displacement is plotted on the y-axis and time squared is plotted on the x-axis, the resulting slope of the graph should be equal to one half the acceleration (**0.5a**). Here, the acceleration was 0.6 m/s², so **0.5a** = 0.3. Consider your slope. Is your calculated slope within 10% (±0.03)?



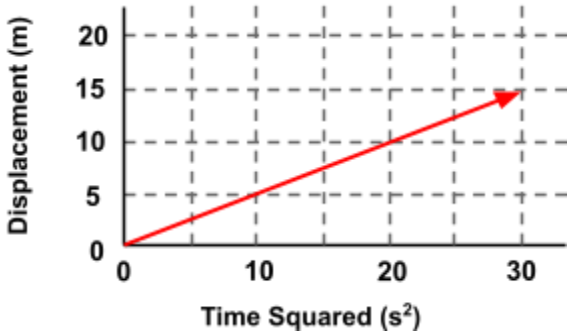
____ Yes ____ No

4. Consider the two graphs below, which show the displacement as a function of time squared. For each graph, calculate the slope of the graph and then use that to determine the acceleration of the object.



Slope: _____

Acceleration: _____



Slope: _____

Acceleration: _____