

Unit 1 ~ Learning Guide Name: _____**Instructions:**

Using a pencil, complete the following notes as you work through the related lessons. Show ALL work as is explained in the lessons. You are required to have this package completed BEFORE you write your unit test. Do your best and ask questions if you don't understand anything!

Math in Physics:

1. Convert the following to scientific notation in standard form.

- | | | |
|----|-----------|-------|
| a) | 34674 | _____ |
| b) | .000235 | _____ |
| c) | -2300000 | _____ |
| d) | -.0000150 | _____ |
| e) | 0.00750 | _____ |

2. Indicate the number of **significant figures** in the number given (ans.

- | | | |
|----|---------------------|-------|
| a) | 120000 | _____ |
| b) | 32100.0 | _____ |
| c) | .00123 | _____ |
| d) | 0.20040 | _____ |
| e) | 730.01 | _____ |
| f) | 0.0300 | _____ |
| g) | 7.590×10^3 | _____ |
| h) | 9×10^{-4} | _____ |

3. Evaluate the following and use the correct number of **significant figures** in your answer (Show all work)

- a. 2.35 cm x 4.6 cm

b) $\frac{4}{3} (3.14159)(4.7 \text{ in})^3$

c) $\frac{(-1.25\text{m})(3.2\text{m})}{3.4\text{m}}$

d) $\frac{33560000000 \times .00000012\text{km}}{24.5\text{hr}}$

e) $2301\text{cm} + 834.12\text{cm} + 9.0\text{cm}$

4. Rearrange the equation, solving for the variable shown (clearly show all steps).

a. Solve for Q_1 where $F = \frac{kQ_1Q_2}{r^2}$

b. Solve for "t" where $d = \frac{1}{2}at^2$

c. Solve for v_o where $d = \left(\frac{v_o + v_f}{2} \right) t$

d. Solve for "a" where $v_f^2 = v_i^2 + 2ad$

e. Solve for d_f where $v = \frac{d_f - d_i}{t_f - t_i}$

f. Solve for m where $E_p = mgh$

g. Solve for m where $E_k = \frac{1}{2}mv^2$

h. Solve for t_i where $v = \frac{d_f - d_i}{t_f - t_i}$

i. Solve for v_o where $d = v_o t + \frac{1}{2} a t^2$

j. Solve for v_i where $v_f^2 = v_i^2 + 2ad$

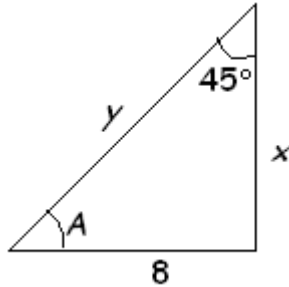
k. Solve for v_f where $d = \left(\frac{v_o + v_f}{2} \right) t$

l. Solve for v where $E_k = \frac{1}{2} m v^2$

m. Solve for t where $d = v_o t + \frac{1}{2} a t^2$

5. Solve the following triangles using SOHCAHTOA and Pythagoras. Show all work.

a) Solve for x , y , and A .

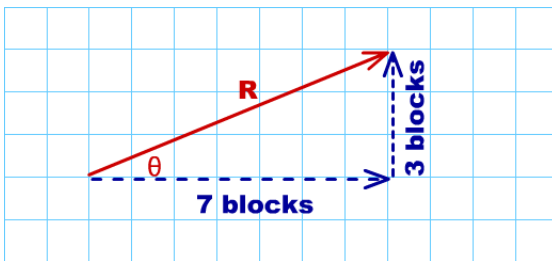


$x =$ _____

$y =$ _____

$A =$ _____

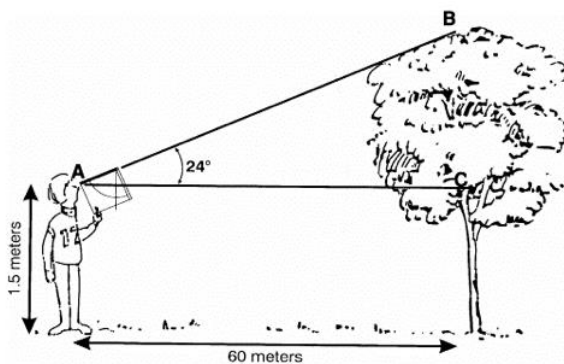
b) Solve for R and θ .



$R =$ _____

$\theta =$ _____

c) Solve for R and θ .



$BC =$ _____

Total Height = _____

6. Unit conversions (**show all work – lay out in brackets, same as lesson examples**)

a. 2.67 hours into seconds

b. 80 km/hr to m/s

c. 34 km into meters

d. 1 day into seconds

e. 12 hours into seconds

f. 100 km/hr into m/s

g. 40 km/hr into m/s

h. 12 m/s into km/hr

i. 200 g into kg

j. 10 kg into grams

7. Suppose that the water level of a river is 34 meters and that it is receding at a rate of 0.5 meters per day. Write an equation for the water level, L , after d days. In how many days will the water level be 26 meters? (include units for everything)

8. A plumber charges \$25 for a service call plus \$50 per hour of service. Write an equation in slope-intercept form for the cost, C , after h hours of service. (include units for everything)

9. A runner gets a 30 meter head-start then runs 5 km/hr. Write an equation (in base SI units) which will represent the runners distance from the start line at any second. (include units)

10. A car begins at a speed of 20 m/s then increases its speed by 2.0 m/s each second. Write an equation that represents the speed of the car as a function of time. (include units)

Kinematics Review:

1. The acceleration of a freely falling object (near Earth), when we assume no air resistance, is _____ (remember units). This acceleration (due to gravity) is also called the _____ and is represented by the letter _____.
2. The assumption of no air resistance is never totally true, but is often close enough to make pretty accurate calculations. Discuss cases where this is a really good assumption and when it isn't.

3. As difficult as it is to visualize the changes in velocity, a good understanding of acceleration is needed to master kinematics problems. Recognizing that acceleration can be positive, while velocity is positive (and visa) is definitely brain exercise.

- a. Object is speeding up (from still) in the positive direction. For example, a ball is placed on a slanted ramp.

Velocity is positive / zero / negative and increasing / constant / decreasing.

Acceleration is positive / zero / negative.

- b. Object is speeding up (from still) in the negative direction. For example, a ball is placed on a ramp that is slanted towards the negative direction (eg. down to the left).

Velocity is positive / zero / negative and increasing / constant / decreasing.

Acceleration is positive / zero / negative.

- c. Object is slowing down in the positive direction. For example, you push a ball up a slanted ramp.

Velocity is positive / zero / negative and increasing / constant / decreasing.

Acceleration is positive / zero / negative.

- d. Object is slowing down in the negative direction. For example, you push a ball up a ramp that is slanted towards the negative direction (eg. down to the right).

Velocity is positive / zero / negative and increasing / constant / decreasing.

Acceleration is positive / zero / negative.

4. Review your results from the previous question to build general statements that are always true:

Acceleration is always in the opposite direction of _____ if the object is slowing down.

Acceleration is always in the same direction of _____ if the object is speeding up.

5. Show what happens to each of the following kinematic equations when the acceleration is zero ($a=0$). Once you have simplified, interpret, in words, what the equation is telling us. One equation is done for you. Keep in mind that the kinematic equations are always valid for motion with constant acceleration. However, they are not always useful...

$$a = (v_f - v_0)/t$$

If $a = 0$ we get

$$0 = (v_f - v_0)/t$$

For this equation to be true this means that

$$0 = (v_f - v_0)$$

Or

$$v_f = v_0 \text{ (velocity is constant if acceleration is zero)}$$

i. $d = v_0 t + \frac{1}{2} a t^2$

ii. $v_f^2 = v_0^2 + 2ad$

6. A stationary boat accelerates to 90 km/hr over 1 km. What is the time it takes to do this?

11. Hikers at the bottom of a canyon are facing towards the canyon wall 280.5 meters away. Given that the speed of sound in air is 340 m/s, how long after they should will they hear their echo?

12. A child on a toboggan slides down a snowy hill, accelerating uniformly at 2.8 m/s^2 . When the toboggan passes the first observer, it is travelling with a speed of 1.4 m/s. How fast will it be moving when it passes a second observer, who is 2.5 m downhill from the first observer? **Show all work** as demonstrated in the lessons.

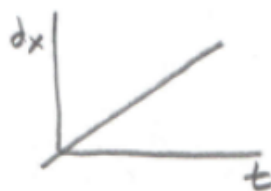
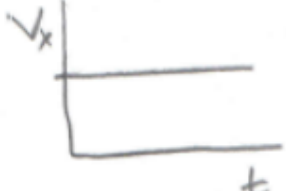
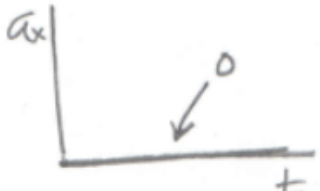
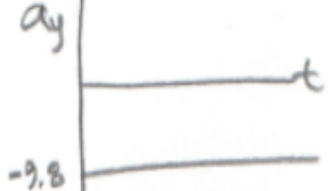
13. A semi-loaded train travelling at 100 m/s can decelerate at 20 m/s^2 . How far in advance must the brakes be applied to come to a stop?

14. A bike rider accelerates constantly to a velocity of 7.5 m/s during 4.5 s. The bike's distance is 19m. What is the initial velocity of the bike?

15. A cyclist moving with constant velocity of 6.0 m/s forward passes a car that is just starting. If the car has constant acceleration of 2.0 m/s^2 , where and when will the car overtake the cyclist (ie. they are both the same distance from the starting point)? **Show all work** as demonstrated in the lessons.
16. A stone is dropped from the top of a tall building. It accelerates at a rate of 9.81 m/s^2 . How long will the stone take to pass a window that is 2.0 m high, if the top of the window is 20.0 m below the point from which the stone was dropped? HINT: draw a picture for starters. **Show all work** as demonstrated in the lessons.

17. Provide a description of a sample situation for each of the graphs below (make sure to recognize each graph as d vs t , v vs t , or a vs t).

18. Sketch the basic graph shapes (and add values where appropriate) for the various projectile problems. Some have been done for you – make sure you understand them.

	Type 1	Type 2	Type 3
Example Situation (canon)			
special	$V_{yo} = \underline{\hspace{2cm}}$	$d_y = \underline{\hspace{2cm}}$	$V_{yo} \neq \underline{\hspace{2cm}}, d_y \neq \underline{\hspace{2cm}}$
d_x vs t			
d_y vs t			
v_x vs t			
v_y vs t			
a_x vs t			
a_y vs t			

19. To help you remember better, sketch a representation of the relationships between d vs t , v vs t , and a vs t graphs, in terms of slopes and areas. (Note: FYI, this summary is the very basis of the study of Calculus).

Vectors:

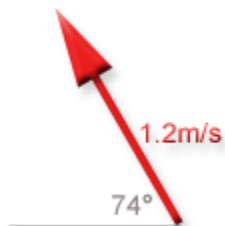
1. Convert the following into vertical and horizontal components. Show all steps and include units.
- a)



b)



c)



2. Break the following vectors into components (remember directions) - **show work** by sketching each vector, labeling the angle and showing components!

a) 25 [35° N of E]

x _____

y _____

b) 373 [12° E of N]

x _____

y _____

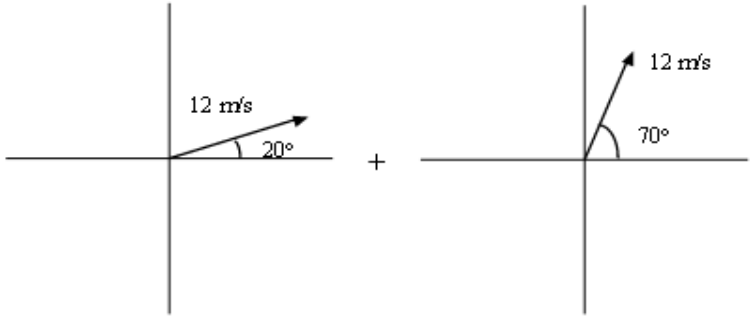
c) 126 [22° N of W]

x _____

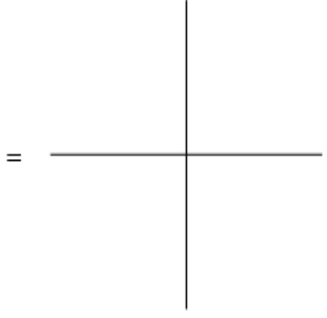
y _____

3. **Add** the following vectors together using the **component** method.

a.



Sketch Resultant



$X_1 = \underline{\hspace{2cm}}$
 $Y_1 = \underline{\hspace{2cm}}$

$+$

$X_2 = \underline{\hspace{2cm}}$
 $Y_2 = \underline{\hspace{2cm}}$

$+$

$X_{\text{tot}} = \underline{\hspace{2cm}}$
 $Y_{\text{tot}} = \underline{\hspace{2cm}}$

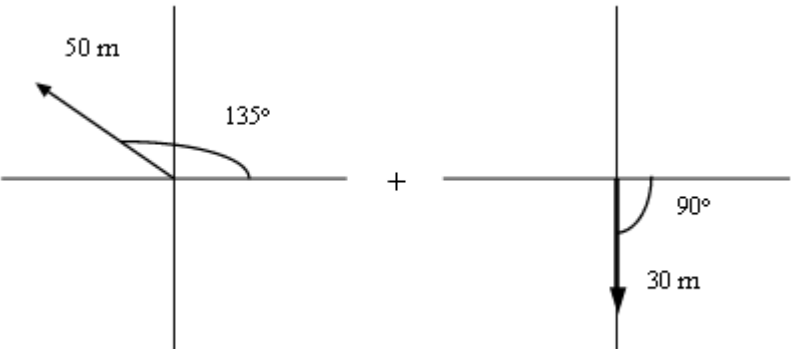
Magnitude of Resultant
(hypotenuse)

 $R = \underline{\hspace{2cm}}$

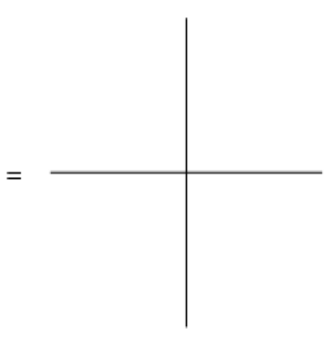
Direction of Resultant (find angle)

 $\Theta = \underline{\hspace{2cm}}$

b.



Sketch Resultant



$X_1 = \underline{\hspace{2cm}}$
 $Y_1 = \underline{\hspace{2cm}}$

$+$

$X_2 = \underline{\hspace{2cm}}$
 $Y_2 = \underline{\hspace{2cm}}$

$+$

$X_{\text{tot}} = \underline{\hspace{2cm}}$
 $Y_{\text{tot}} = \underline{\hspace{2cm}}$

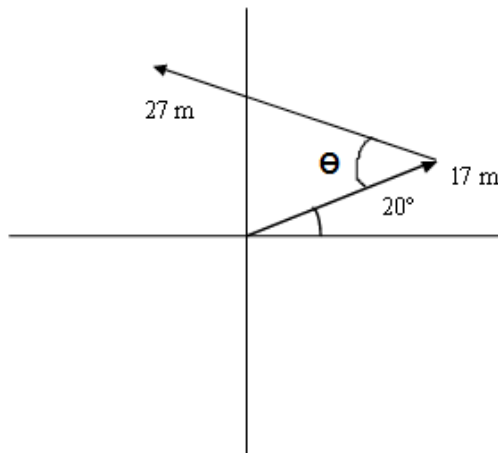
Magnitude of Resultant
(hypotenuse)

 $R = \underline{\hspace{2cm}}$

Direction of Resultant (find angle)

 $\Theta = \underline{\hspace{2cm}}$

4. A man walks 17m in a direction that is 20° N of E. He then changes direction and walks another 27m at 30° N of W. The two vectors are added together tip-to-tail as shown below. What is his overall displacement? Use the trig method (ie. The sine and cosine laws)



- Determine the angle, Θ , as shown above (it often helps to draw another x-y axis at the start (tail) of the second vector)
- Draw in the resultant and label it R. Be sure to draw in the arrowhead to show its direction.
- Using the Cosine Law, determine the magnitude of R. Show all work below.
- Use the Sine Law to determine all of the angles in your triangle above (hint: Never use the Sine Law if the angle MIGHT be greater than 90° . Always solve for the small, acute, angle, then use the fact that they must add to 180° to determine the other.) Show all work below and label angles onto diagram above.
- To properly specify the final direction of your resultant above, you need to provide an angle that is referenced to either the horizontal axis (x-axis) or the vertical axis (y-axis). Determine the final direction N of W that your resultant is pointing (find the angle between R and the negative x-axis).

- Can three parallel vectors unequal in magnitude add to zero? Show with a vector diagram below.
- Can three vectors of different magnitudes and directions add to zero? Show with a vector diagram below.
- The kinematic equation $d = vt$ is used in conjunction with relative velocity questions. Explain why the other kinematic equations are not useful for most relative velocity questions.

8. Two swimmers of identical ability want to race across a river. The goal is to touch the other side first (anywhere along the bank). Both swimmers can swim at a rate of 5m/s in still water. The river's current is 3m/s. Swimmer A points upstream so that she ends up travelling straight across the river along a line perpendicular to the point on the shore where she started. Swimmer B points directly across and ends up downstream due to the river's current.
- Which swimmer makes it across first? Why do you think this is so?
 - If the river is 50m wide determine the time it takes for each swimmer to cross.
 - Using swimmer B above solve for the following: Construct the equivalent displacement vector diagram and label all sides and angles with correct values. Use the equation $d = vt$ and solve for t in each direction (i.e time to travel downstream, time to travel diagonally).
 - How far downstream does Swimmer B end up?
9. An airplane travels with an airspeed of 400 km/h NE (in still air). Wind blows **from** the North at 50km/h.
- Break down both given velocities into components. Draw the original vectors roughly to scale and label the values of the x-y components directly on the sketch.

- b. What component does wind affect? How does this affect the overall **airspeed** as seen from an observer on the ground? Remember “speed” is scalar. I am really asking if the plane speeds up or slows down overall.
 - c. What is the final **velocity** as seen from the ground? We call this $\mathbf{v}_g$ for velocity with respect to ground.
10. Repeat the above question with the airspeed initially at 400km/h NW. This time the plane ENDS UP flying at 300 km/h 30° N of W.
- a. What do we call the 300 km/h velocity that the plane ends up at? (refer to previous question)
 - b. Break down each of the given vectors into components. Draw and label scaled diagrams as you did in the previous question.
 - c. How much has the plane’s resulting velocity changed in the x (E – W direction) from the previous problem? What caused this change?

- d. How much has the plane's resulting velocity changed in the y (N – S direction) from the previous question? What caused this change?

- e. Using your results above what are the wind's components? What is the overall wind velocity?

- 11. A jet aircraft is aimed south and travelling 851 km/h. A wind blows the plane toward the east at 36.0 km/h. What is its resultant velocity?

Projectiles:

1. Describe (in your own words) what a projectile is. Provide examples.

2. What is the biggest difference in a projectile's horizontal and vertical motion? What phenomenon causes this difference?

3. Summarize the (often) surprising result of shooting a gun and dropping a bullet at the same time. Why is this true (explain in terms of horizontal and vertical components of motion)?

4. Consider the monkey dropping problem from your lessons (ie. shooting a dropping monkey).
 - a. Where must you aim the rifle for you to hit the falling monkey? Why?

 - b. What if you had a gun with a higher muzzle-velocity? Ie. the bullet reaches the monkey faster. Why?

 - c. Change the height of the monkey to its maximum and repeat. Explain where you must aim the arrow and why it works?

5. You are exploring a newly discovered cave in the Andes in South America. Peering over the edge of a cliff in the cave, you can't see the bottom. Wondering if you have enough rope to rappel to the ground, you drop a rock off the top, and hear the sound of it hitting the bottom 4.2 seconds later. Find the height of the cliff ignoring the time that the sound takes to travel back to you from the bottom. **Show all work** as done in lessons .

6. 0.30 s after seeing a puff of smoke rise from the starter's pistol, the sound of the firing of the pistol is heard by the track timer 100 m away. What is the velocity of sound? Hint: treat the speed of light as instantaneous.

7. A boy throws a rock straight up into the air. Explain the changes taking place through the flight in terms of velocity and acceleration.

8. A stone is thrown horizontally at 15 m/s from the top of a cliff 44 meters high.
 - a) How long does the stone take to reach the bottom of the cliff? **Show all work** as done in lessons.

 - b) How far from the base of the cliff does the stone strike the ground? **Show all work** as done in lessons.

9. A golfer hits a ball at a 40 degree angle with an initial speed of 35 m/s. How far does it travel before it hits the ground?
10. A golf ball is struck and leaves the ground at 48 m/s on a 60 degree angle.
 - a. How long will it be in the air before bouncing?
 - b. How far will the ball in the previous example travel in the air before the first bounce?
 - c. Determine the velocity of the ball 2 seconds after it was struck.
 - d. The most common incorrect answer for this question is 22m/s. What has actually been calculated if this is the answer?

11. A football is kicked off at 40 degrees to the field at a velocity of 24 m/s. What is the range of this kick?
12. What is the maximum height of a rock launched by a sling shot at 50 m/s on an angle of 80 degrees?
13. A soccer player kicks a ball from ground level at 27 m/s at an angle of 30 degrees above the horizontal.
a) What is the "hang time" (time in the air) of the ball? **Show all work** as done in lessons.
.

b) How far does the ball travel before hitting the ground? **Show all work** as done in lessons.
14. A grade 12 Physics student shoots a basketball from the ground at a hoop which is 2.0 m above her release. The shot was at a velocity of 15 m/s and at an angle of 70 degrees to the ground. What was the distance to the hoop if the shot was good? Note: components have been found for the initial velocity.

15. Find the range for a basketball thrown at 6.0 m/s at an angle of 50° above the horizon if it leaves from a height of 2.0m.

16. Calculate the range of a rock thrown from the top of a 30 m high cliff. The rock is thrown at 8.0 m/s at 30 degrees down from the horizontal.

17. During the filming of a TV show, a stuntman runs horizontally off the edge of the roof of a building 49 m high, with a horizontal velocity of 3.6 m/s.
 - a. For how many seconds will the falling stuntman be in the air?

 - b. How far out from the edge of the building should the safety bag be placed so that he can fall without being hurt?

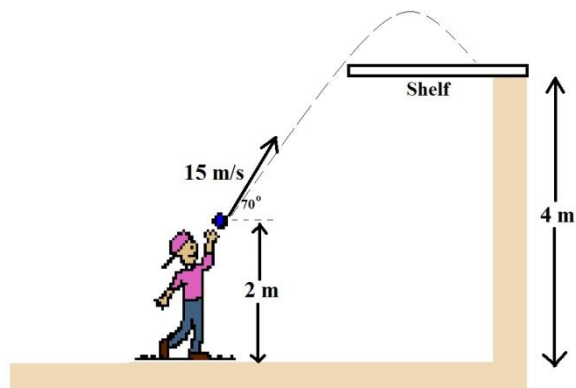
18. What is the maximum distance a baseball pitcher could throw a ball on the moon, if he throws it with a velocity of 36.0 m/s at an angle of 45.0° above the horizontal? ($g = -1.6 \text{ m/s}^2$)

19. A grade 12 Physics student shoots a basketball from the ground at a hoop which is 2.0 m above her release. The shot was at a velocity of 10 m/s and at an angle of 80° to the ground.

a. Determine the vertical velocity of the ball when it is at the level of the net. You should get two answers.

b. Using your answer to (a) determine the time of flight for the ball (from release to basket).

c. When solving projectiles you will often get two possible times for solutions. Sometimes a time will be negative and can be rejected. Other times both times will be positive and therefore possible. **Explain** why both times above make sense in the context of the given information used. Which time will you ultimately choose and why? Use the diagram to label where the rock is at the two times found above. Label the heights at these points with a dotted, horizontal line.



Answers:

Math in Physics:

1) 3.4674×10^4 , 2.35×10^{-4} , -2.3×10^6 , -1.50×10^{-5} , 7.50×10^{-3} 2) 2,6,3,5,5,3,4,1 3) 11 cm^2 , 430 in^3 , -1.2 m , 160 km/hr , 3144 cm

$$4) \text{ a) } Q_1 = \frac{Fr^2}{kQ_2} \quad \text{b) } t = \sqrt{\frac{2d}{a}} \quad \text{c) } v_o = \frac{2d - v_f t}{t} \quad \text{d) } a = \frac{v_f^2 - v_i^2}{2d} \quad \text{e) } d_f = vt_f - vt_i + d_i$$

$$\text{f) } m = \frac{E_p}{gh} \quad \text{g) } m = \frac{2E_k}{v^2} \quad \text{h) } T_i = \frac{vt_f + di - d_f}{v} \quad \text{i) } v_o = \frac{d - \frac{1}{2}at^2}{t} \quad \text{j) } vi = \sqrt{vf^2 - 2ad}$$

$$\text{k) } v_f = \frac{2d - v_o t}{t} \quad \text{l) } v = \sqrt{\frac{2E_k}{m}} \quad \text{m) } t = \frac{-v_o \pm \sqrt{v_o^2 + 2ad}}{a}$$

5) a) $x=8$, $y=11$, $A=45^\circ$ b) $R=8$, $\Theta=23^\circ$ c) 26.7 m , 28.2 m

6) a) 34000 m d) 86000 s e) $4.3 \times 10^4 \text{ s}$ f) 28 m/s g) 11.1 m/s h) 43.2 km/h i) 0.2 kg j) 10000 g

7) $L = -0.5d + 34$, 16 days 8) $C = 50h + 25$ 9) $d = 1.4t + 30$ 10) $v = 2.0t + 20$

Kinematics Review:

1) 9.8 m/s^2 , grav constant, g 3) a) pos, inc, pos b) neg, dec, neg c) pos, dec, neg d) neg, inc, pos
4) velocity, velocity 6) 80s 7) 2469 m 8) 0.87 m/s^2 9) 2.9 s 10) 80 s 11) 1.65 s 12) 4.0 m/s
13) 250 m 14) 0.9 m/s 15) 6.0s 16) 0.10s

Vectors:

1) a) $v_x = 27 \text{ m/s}$, $v_y = 22 \text{ m/s}$ b) $v_x = 180.7 \text{ m/s}$, $v_y = -58.7 \text{ m/s}$ c) $v_x = -0.33 \text{ m/s}$, $v_y = 1.15 \text{ m/s}$
2) a) 20.5 E, 14.3 N b) 365 N, 77.6 E c) 116.8 W, 47.2 N 3) a) $X1 = +11.28 \text{ m/s}$, $Y1 = +4.10 \text{ m/s}$, $X2 = +4.10 \text{ m/s}$, $Y2 = +11.28 \text{ m/s}$, $X_{tot} = +15.38 \text{ m/s}$, $Y_{tot} = +15.38 \text{ m/s}$, $R = 21.8 \text{ m/s}$, $\Theta = 45^\circ \text{ NofE}$, b) $X1 = -35.36 \text{ m}$, $Y1 = +35.36 \text{ m}$, $X2 = 0 \text{ m}$, $Y2 = -30 \text{ m}$, $X_{tot} = -35.36 \text{ m}$, $Y_{tot} = +5.36 \text{ m}$, $R = 35.8 \text{ m}$, $\Theta = 8.6^\circ \text{ NofW}$
4) a) 50° , b) points NofW, c) $R = 20.7 \text{ m}$, d) $\Theta = 69^\circ \text{ NofW}$ 5) Yes 6) Yes 7) $a \neq 0$ 8) a) B b) 12.5s, 10s c) 50m, 30m, 58m d) 30m 9) a) 283 km/h , 233 km/h b) lower c) 366 km/hr @ 40° NofE
10) a) ground vel c) -23 km/hr d) -83 km/hr e) 135 km/hr @ 80° SofE 11) 852 km/hr @ 2.4° EofS

Projectiles:

2) acceleration, F_g 4) at, at, at 5) 86m 6) 330m/s 7) $a = \text{same}$, v goes from pos to zero to neg
8) a) 3.0s b) 45m 9) 123 m 10) a) 8.5 s b) 204 m c) 32.6 m/s 11) 57.8 m 12) 123.5 m
13) 2.7 s, 65 m 14) 14m 15) 4.9m 16) 14.6m 17) a) 3.2s b) 11m 18) 810m 19) a) $\pm 7.6 \text{ m/s}$ b) 1.8s