AP Physics 1 – Summer Assignment

Welcome to AP Physics 1! We are looking forward to having you in class this year and sharing our excitement for physics with you.

AP Physics 1 is an algebra-based course that relates matter and energy in order to understand physical phenomena. This course will enable you to improve your critical thinking, physical intuition, and problem solving skills. Among the topics we will cover this year are: motion, force, energy, momentum, rotation, simple harmonic motion, waves, electricity, and circuits.

You will receive a textbook for the course in September. The textbook for this course is *College Physics* by Etkina, Gentile, and Van Heuvelen.

This summer assignment contains two parts. Part 1 is a review of science and mathematics topics necessary to be successful in AP Physics 1. Part 2 requires you to study the concepts, methods and equations of kinematics. You will complete 39 kinematics practice problems. Your solutions must be **NEAT**, **complete** and **labeled**. The correct solution is only a part of the answer. You will receive credit for showing work and labeling answers with units.

Part 1 and the 39 practice problems will be **graded for correctness** and are due **the first day of school, September 5, 2019**, or you will earn a zero. In addition, for or part 2, during the first week of class, you will take a quiz on kinematics. Concepts and resources to help with your study of kinematics are on the reverse side of this sheet.

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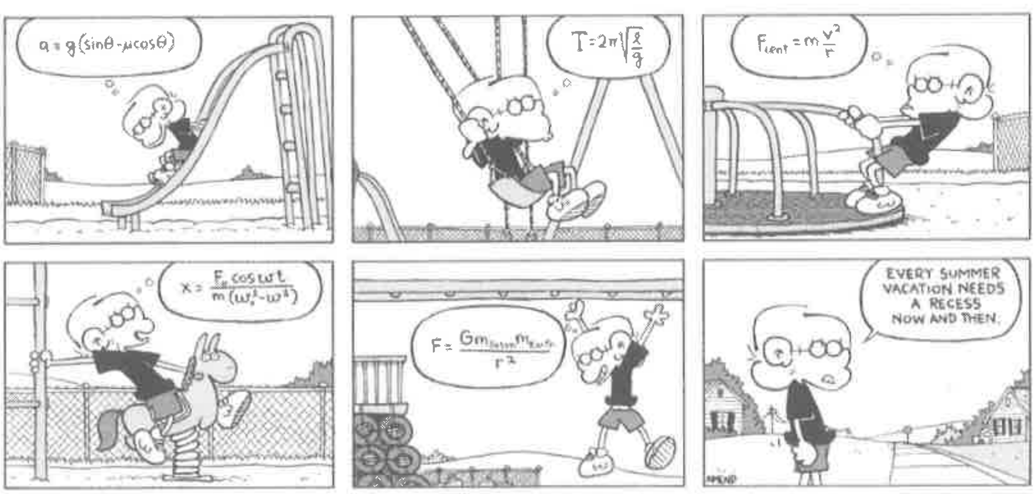


Foxtrot by Bill Amend

Concepts: distance, displacement, time, scalar, vector, speed, velocity, acceleration, free fall motion, motion diagrams, motion graphs

Resources:

Textbook Chapter 1: Kinematics: Motion in One Dimension pgs. 2-34

Websites/Videos:
The Physics Classroom: https://www.physicsclassroom.com/Physics-Tutorial/1-D-Kinematics

Professor Dave YouTube: Classical Physics – Kinematics: https://youtu.be/4dCrkp8qgLU

Ms. Twu's physics videos: https://sites.google.com/site/twuphysicslessons/home/kinematics
Videos: 1 - 15

Texas Gateway physics videos: https://www.texasgateway.org/binder/chapter-3-kinematics

Name: ______________________________________

Part 1: Science and Math Basics

For all problems, show your work in the space below the problem. I am interested in your problem solving method as well as your answer. ***You will be graded on both.***

Base Units

mass	kilogram (kg)
length	meter (m)
time	second (s)
electric current	ampere (A)
temperature	kelvin (K)
amount of substance	mole (mol)
luminous intensity	candela (cd)

Metric Prefixes

mega- (M-)	10^6	1 million
kilo- (k-)	10^3	1 thousand
centi- (c-)	10^{-2}	1 hundredth
milli- (m-)	10^{-3}	1 thousandth
micro- (μ-)	10^{-6}	1 millionth
nano- (n-)	10^{-9}	1 billionth

<u>**SI Units**</u> – Units are important both in communicating answers and solving problems. Understanding how units relate to each other will help you solve problems and check your answers. Read background information on SI Base Units and derived units from the NIST website (http://physics.nist.gov/cuu/Units/units.html).

1. Speed is given by the following expression: $speed = \frac{distance}{time}$. Determine the derived units for speed.

2. Frequency is given by the following expression: frequency = speed / wavelength
   Determine the derived units for frequency. (Hint: wave<u>length</u> is a length measurement.)

3. Momentum is given by the following expression: $momentum = mass * speed$. Determine the derived units for momentum.

4. In Einstein's famous equation $E = mc^2$, m is mass, c is the speed of light, and E is energy. Using unit analysis, determine the derived units for energy (also called the Joule).

Dimensional Analysis– Sometimes the units given in a problem or collected in the lab are not the most convenient or useful. It is important to be able to convert from one set of units to another. Use dimensional analysis to solve the following problems. (Take a look at this link for background information if you need it. (http://www2.southeastern.edu/Academics/Faculty/wparkinson/help/dimensional_analysis/)

5. The speed of light, *c*, is 3.00×10^8 m/s. What is it in mi/hr? Express this in scientific notation. (There are 1609 m in a mile.)

6. How many mg are there in 45 kg?

7. Convert 37 cm^3 to m^3.

8. Convert 1.5×10^5 fathoms/lunar month to meters/second. (1 lunar month lasts 29 days, 12 hours, 44 minutes and 3 seconds.)

9. Order the following measurements from *smallest to largest*. Note that I am *not* asking you if *one* second is longer or shorter than *one* ns, but if 4×10^{-3} s is longer or shorter than 3.6 ns.
   A) 0.008 μs B) 3.6 ns C) 3×10^{-10} Ms D) 4×10^{-3} s

10. If light travels at 3.00×10^8 m/s, how long does it take light from our Sun, 1.5×10^{11} m away, to reach Earth? Express this in minutes.

Algebraic Equations– Solving algebraic equations is a critical skill required to interpret relationships between physical quantities as well as to solve for a particular value.

11. Solve the following equations for the specified variable.

a. Solve for a: $v_f = v_i + at$ ____________________

b. Solve for v: $F_c = \frac{mv^2}{r}$ ____________________

c. Solve for m_1: $F = \frac{Gm_1m_2}{r^2}$ ____________________

d. Solve for g: $T = 2\pi\sqrt{\frac{l}{g}}$ ____________________

e. Solve for x: $E = \frac{1}{2}kx^2$ ____________________

f. Solve for v_i: $\Delta x = v_i t + \frac{1}{2}a\,t^2$ ____________________

Algebraic Relationships

For the following equations, fill in the blank to explain how the variables relate to each other. For 12-14 use words like increases, decreases, or stays the same.

12. $z = \frac{x}{y}$

i. As *x* increases and *y* stays constant, *z* ________________.

ii. As *y* increases and *x* stays constant, *z* ________________.

iii. As *x* increases and *z* stays constant, *y* ________________.

13. $c = ab$

i. As *a* increases and *c* stays constant, *b* ________________.

ii. As *c* increases and *b* stays constant, *a* ________________.

iii. As *b* increases and *a* stays constant, *c* ________________.

14. $p = m\sqrt{n}$

i. As *n* increases and *m* stays constant, *p* ________________.

ii. As *p* increases and *n* stays constant, *m* ________________.

15. $r = \frac{s^2}{t^2}$

i. If *s* is tripled and *t* stays constant, *r* is multiplied by ________________.

ii. If *t* is doubled and *s* stays constant, *r* is multiplied by ________________.

AP Physics 1 Summer Assignment Part 2: Kinematics Problems

Do your work on a separate piece of paper. Show ALL work for total credit.

1. Suppose you buy a new car and its odometer shows 15 miles. However, the displacement of the car since it was first manufactured may be hundreds or even thousands of miles. (a) Does the odometer show the true distance traveled by the car since it was manufactured? Explain. (b) Suppose that on a future date the odometer shows 100000 miles but the displacement is actually zero – what would cause this? Explain.

2. Assume the field in a stadium runs perfectly north and south. Beginning with an initial position of 60.0 yds., 90.0° from the south goal post, a student walks (in linear segments) the following four displacements in succession: $\mathbf{d}_1$ = 10.0 yds, 0.0°, $\mathbf{d}_2$ = 11.2 yds, 206.6°, $\mathbf{d}_3$ = 11.2 yds, 333.4°, $\mathbf{d}_4$ = 10.0 yds, 180.0°. (a) Using a protractor and ruler *measure* and construct a scale diagram of the student's walk. (b) From initial to final position what is the overall displacement? (Hint: measure your diagram!) (c) From initial to final position what is the total distance? (d) What is the final position?

3. The speed of light in the vacuum of space or in air is a constant value of 3.00×10^8 m/s. (a) Calculate the distance traveled by light in one year's time (known as a "light-year"). (b) What amount of time does it take for light to travel from the Moon to the Earth – a distance of 384,000,000 m? (c) How much time would it take a car traveling 45 m/s (100 mph)?

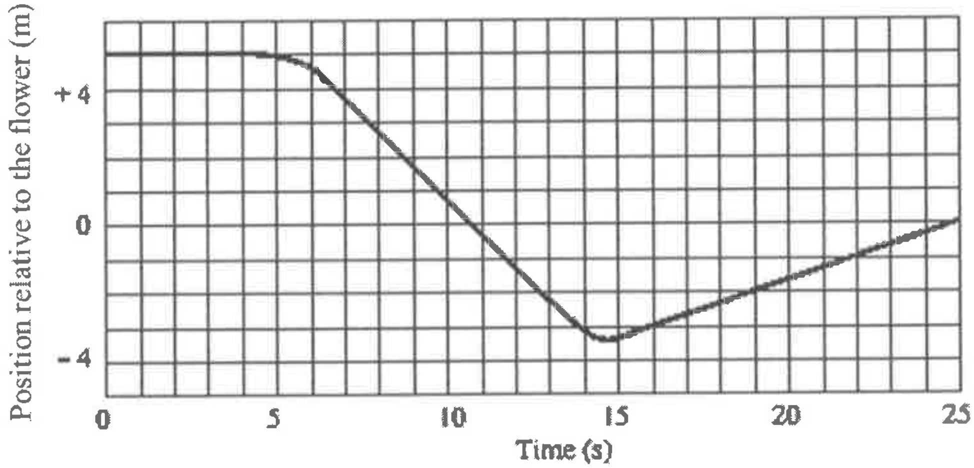
4. An airport radar uses the reflection (or "echo") of a radio signal to measure aircrafts' positions. Suppose the position of a certain helicopter at 1:00 PM is 105 miles, 90.0° from the airport. At 1:30 PM it is 48 miles, 90.0° from the airport. (a) Find the displacement of the helicopter over this interval of time. (b) Find the average velocity of the helicopter. (c) If the velocity remains constant what will be the position of the helicopter at 1:45 PM? Note: a diagram showing the airport and helicopter is *very* helpful!

5. You are driving down a street in a car at 85 km/h. Suddenly a deer darts into the street. If it takes you 0.75 s to react and apply the brakes, how many meters will you travel before you begin to slow down?

6. Suppose you need average speed of 100 km/h to arrive at a certain destination on time. However, traffic limits your average speed to only 60 km/h during the first half of the trip's distance. (a) What must your average speed be in the second half of the trip to be on time? (b) Regardless of how fast you drive in the second half you can only improve your overall average speed so much. Determine the *greatest possible* average speed for the entire trip – derive and/or explain.

7. An airplane is accelerating along a linear flight path and has average velocity 400 mph, north from 1:00 pm to 1:02 pm. The plane's instantaneous speed may or may not be equal to 400 mph at 1:01 pm. Make a careful sketch of a distance vs. time graph (showing these two minutes of flight) illustrating three possibilities: the instantaneous speed is less than, greater than, or equal 400 mph at 1:01 pm.

8. The graph below shows the motion of a hummingbird. Positive positions indicate the direction East. For the interval of time shown, determine the following: (a) Determine the time and position when the bird is farthest west of the flower. (b) Determine the bird's average velocity. (c) Determine its average *speed*. (d) What is the bird's velocity at 10.0 s? (e) Determine the speed at $t = 5.5$ s, and explain whether it is increasing, decreasing, or constant at that point. (f) At what position(s) is the bird's velocity equal to zero? (g) What is the bird's maximum speed?



9. A 1956 VW Van could go from 0 to 60 mph (26.8 m/s) in 75 seconds (as measured by *Road & Track*). (a) Determine the average rate of acceleration. (b) Assuming a braking deceleration of 9.0 m/s^2 what amount of time was required to return from 60 mph to 0?

10. In the 1940's rocket-powered sleds were used to test the responses of humans to acceleration. Suppose the sled reaches a speed of 222 m/s in 2.10 s and then in another 0.90 s is brought to a stop. Determine the greatest number of *g*'s (in any direction) experienced by the rider. (A "*g*" is an acceleration rate equal to 9.80 m/s^2.)

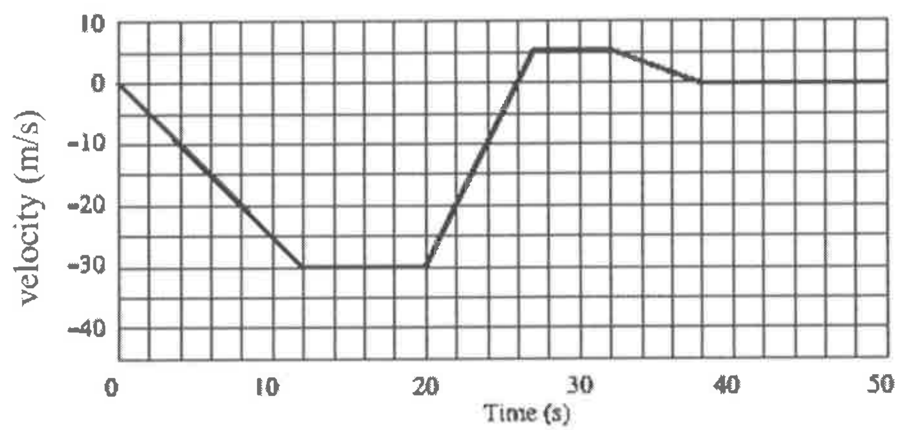
11. An F-22 fighter jet is flying at a "supercruise" speed of 545 m/s when the pilot kicks in the afterburners. The afterburners cause an acceleration rate of 3.47 m/s^2. How much time is needed to reach a speed of 600 m/s (Mach 2.0 or twice the speed of sound!)?

12. A baseball with an initial velocity of 40.0 m/s, south undergoes an average acceleration of 1.15×10^5 m/s^2, northward due to the impact of a bat that is in contact with the ball for 0.75 milliseconds. What is the final velocity of the ball?

13. A 2010 Chevy Camaro went from zero to 20 mph, 40 mph, and 60 mph, in times of 1.1 s, 2.6 s, and 4.6 s respectively. This is an interesting pattern because the average acceleration changes by about the same percentage for every 20 mph faster the car goes. (a) By about what percent does the acceleration rate change per every 20 mph increase? (b) If the pattern continues, what time is required to go from 0 to 80 mph?

14. Answer the following and explain or give an example: (a) Can an object have a speed equal to zero and at the same time an acceleration not equal to zero? (b) Can an object have a constant speed and a changing velocity? (c) Can an object have a constant velocity and a changing speed? (d) Can an object be moving but not accelerating? (e) Can an object have velocity and acceleration vectors that point in opposite directions?

15. The graph below shows the motion of an object. Positive velocity indicates that the object is moving north. For the interval of time shown, determine the following: (a) At what point(s) in time is the object moving southward? (b) Find the maximum speed. (c) Find the average acceleration from $t = 16$ s to $t = 32$ s. (d) Find the acceleration at $t = 4.0$ s and state whether speed is increasing or decreasing at that point. (e) Find the acceleration at $t = 26$ s. (f) The acceleration is zero at what point(s) in time? (g) The speed of the object is decreasing at what point(s) in time?



16. Using the same graph (shown above), determine the displacement of the object during the following intervals of time: (a) from 0 to 12 s, and (b) from 20 to 32 s. (c) Determine the distance traveled by the object from 0 to 50 s.

17. A skateboarder starts from rest atop a slope that is 20.0 m long and accelerates uniformly 2.60 m/s per second down the slope. (a) What is the position of the skateboarder 3.00 s later? (b) What is the speed at that point? (c) How much time overall is needed to go down the slope?

18. You are investigating an accident scene in which several cars wrecked in order to avoid a car skidding to a stop. The skid marks are 65 m long. A skidding car will have a deceleration rate of about 10 m/s^2. How fast was this car going before it began to skid?

19. An object traveling on a horizontal surface with an initial velocity of 12.0 m/s to the right is then accelerated 3.00 m/s^2 towards the left. (a) Calculate the magnitude of this object's displacement at values of time: 0.00, 4.00, and 8.00 s. (b) Calculate the speed for the same times. (c) Describe the motion of the object for this time interval.

20. At $t = 0.00$ s a ball is started rolling up an inclined plane with an initial velocity of 6.00 m/s, 15.0°. At $t = 2.00$ s the ball reverses its direction and begins to roll back down. (a) How far up the slope does the ball travel? (b) Find the ball's acceleration. (c) Find the speed of the ball at $t = 3.00$ s. (d) Find the distance traveled by the ball during these 3.00 seconds. (e) Find the ball's position at $t = 3.00$ s.

21. An object with constant acceleration travels a distance d in amount of time t. Derive expressions in terms of d and t for: a, the magnitude of its acceleration, and v_{max}, the maximum speed, in two cases: (a) its initial speed is zero, and (b) its final speed is zero.

22. (a) Determine the displacement of a plane traveling northward that is uniformly accelerated from 66 m/s to 88 m/s in 12 s. (b) Repeat the calculation for the same plane slowing down from 88 m/s to 66 m/s in 12 s and show that the result is the same.

23. The bullet leaves the muzzle of a Glock 17 pistol with a speed of 375 m/s. The barrel of the pistol is 11.4 cm long. Find the acceleration rate of the bullet passing through the barrel.

24. A moving car decelerates for 5.0 s and comes to a complete stop. It travels 75 m in the process. (a) Determine its initial value of speed. (b) Determine its rate of deceleration.

25. The driver of a van "times the light" and passes through an intersection at constant speed 15.0 m/s just as the light turns green. At the same time a car in the adjacent lane accelerates from rest at 3.0 m/s^2. (a) What distance must the car travel in order to catch up to the van (and then pass)? (b) What is the speed of the car as it passes the van?

26. Highway safety engineers design "soft" crash barriers so that cars hitting them will slow down at a safe rate. A person wearing a safety belt can withstand a deceleration rate of 300 m/s^2. How thick should barriers be to safely stop a car that hits the barrier at 110 km/h and then slows to a stop as it crashes through and destroys the barrier?

27. An object moves along a linear path with *constant* acceleration. Show mathematically that the *average* velocity of this object over any interval of time is equal to the *instantaneous* velocity at a point exactly halfway through that interval of time. Would this be true if the acceleration is *not* constant?

28. A driver of a car going 25.0 m/s suddenly notices a stop sign 40.0 m ahead. The braking deceleration rate of the car is 10.0 m/s^2, but it takes the driver 0.75 s (reaction time) to get the brakes applied. (a) Determine if the car runs the stop sign. (b) Determine the maximum initial speed at which the car could be moving and manage to stop at the sign.

29. Under what circumstances is the effect of air resistance negligible on a falling object? *i.e.* When is the use of $g = 9.80$ m/s^2 most valid?

30. One rock is dropped from a cliff, a second rock is thrown downward. When they reach the bottom, which rock has a greater speed? Which has a greater acceleration? Which reaches the ground in the least amount of time?

31. A stone is dropped into a very deep hole in the ground and it hits the bottom after falling for 2.80 s. (a) How deep is the hole? (b) What is the impact velocity of the stone?

32. Suppose a person drops 20.0 m (about 5 floors) from a burning building and onto an air bag. (a) What will be the person's maximum speed during their fall? (b) Repeat for a drop of 40.0 m.

33. A ball is thrown upward with an initial speed of 15.0 m/s. (a) Find the maximum height attained by the ball. (b) How much time does it take to reach the maximum height? How much time does it take to fall back down? (c) What is the ball's velocity when it reaches its initial position?

34. A punter goofs and punts the football straight up. The hang time (total time in the air) is 4.00 s. (a) What height does the ball reach? (b) What initial velocity in miles per hour does the ball have?

35. A kangaroo jumps to a vertical height of 2.8 m. What is its total time in the air?

36. A juggler throws a beanbag straight up into the air with initial speed 6.00 m/s. The beanbag leaves the juggler's hand 1.50 m above the floor. The juggler fails to catch the beanbag as it falls to the floor. (a) How long is the beanbag in the air? (b) What is its impact speed?

37. Someone in a skyscraper drops an egg on the boss's car. The boss is mad. He asks you to investigate. You discover that a running video camera in the building recorded the egg passing by a 20th floor full-length window that is 3.00 m from ceiling to floor. Reviewing the tape you notice it takes 0.20 s for the egg to pass the window. Each "story" or "floor" of the building is 4.00 m. (a) From how high above the top of the window was the egg dropped? (From which floor?) (b) With what speed did the egg hit the car's roof? (which was level with the floor of the 1st floor)

38. A stunt man hangs from the bottom of an elevator that is rising at a steady rate of 1.10 m/s. At position y = 13.0 m above ground floor, the man lets go and drops freely for 1.50 s before being caught by a rope that is attached to the bottom of the elevator. (a) Calculate the speed of the man at the instant he is caught by the rope. (b) How long is the rope? (c) How near to the ground floor does the man get?

39. A tennis ball is dropped from 1.20 m above the ground. It rebounds to a height of 1.00 m. (a) With what velocity does it hit the ground? (b) With what velocity does it leave the ground? (c) If the ball were in contact with the ground for 0.010 s find its acceleration while touching the ground. (*i.e.* the acceleration of the "bounce")