**AP Physics C: Mechanics Summer Homework**

**WELCOME TO AP PHYSICS**

This summer homework is meant for you to recap the mathematical pre-requisites for the course as well as to cover the first chapter of AP Physics C: Mechanics – 1 Dimensional kinematics. The H.W is due the first day of school. Online resources are mentioned below and should be referenced as needed. A test on the material covered in this H.W will be given at the beginning of the second week of school. It is advisable that you not leave the H.W to the very last minute – that defeats the purpose of the H.W, which is to get you in the zone where thinking happens.

**Math Practice by Topic:**

ALGEBRA

1.  Find the value(s) of x that solve the equation

2.  Find the value(s) of x that solve the equations.

3.  Find the value of x and y that solves the simultaneous equations.

4.  Find the value of x, y, z and t that solves the simultaneous equations.

5.  Using logarithmic identities, write x as a function of t, i.e., in the form x = f(t)

TRIGONOMETRY and VECTORS

6. For the right triangle shown on the right, find the missing side and all the angles.

5

7

7. For the triangle shown on the right, find the missing side and the angles.

11

40°

8

8 (a). Add the vectors graphically (you may use a ruler):

8 (b). Subtract the vectors graphically (you may use a ruler):

9. A boat is sailing due east at 5 m/s. The wind is blowing out of southwest at 6 m/s, i.e., blowing towards northeast at an angle of 40° (40° north of east). The wind changes the boat’s velocity so that the new velocity of the boat is the vector sum of 5m/s due east and 6m/s, 40° north of east. Find the magnitude and direction of the boat’s new velocity. Use analytical methods only, i.e., no graphical methods.

Please review dot product and cross product of vectors.

10 (a). Find  10 (b) Find 

B: Length 15 units

A: Length 10 units

B: Length 15 units

20°

140°

A: Length 10 units

Recall the last chapter from your Precalculus class specifically: 

11.  Find . At what time is = 0?

PHYSICS HOMEWORK

The main topic of Physics study for the summer assignment is referred to as “kinematics”. Some vocabulary words relevant to this unit are: 1-dimensional motion, average speed, average velocity, instantaneous velocity, acceleration, free fall, point particle.

**Online Resources:**

[**http://www.physicsclassroom.com/Class/1DKin/**](http://www.physicsclassroom.com/Class/1DKin/)

This is a great resource to warm up to Physics. The material presented is at the introductory level – no prior knowledge is required and is not at the AP level. You must go through ALL 6 lessons in this chapter – go through each lesson sequentially. This is a great resource for understanding and interpreting position-time and velocity-time graphs.

[**http://ia600506.us.archive.org/7/items/AP\_Physics\_C\_Lesson\_01/Container.html**](http://ia600506.us.archive.org/7/items/AP_Physics_C_Lesson_01/Container.html)

This is a video lesson from the website: <http://www.learnapphysics.com/apphysicsc/kinematics.php>

We will use this resource throughout the year. The website has great multiple-choice questions along with detailed answers to each question on every topic. I suggest you bookmark this site so you can refer to it while preparing for tests.

[**http://research.physics.illinois.edu/per/PHYS211/Player/**](http://research.physics.illinois.edu/per/PHYS211/Player/)

This is a series of physics video lessons that the University of Illinois has made. They are an excellent way to visually understand the material. Questions are built into the mini lessons. Click on 1-D Kinematics

[**http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html**](http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html)

This a physics concept map based website designed by Georgia State University. Here you will find excellent graphics and a nice overview of concepts.

1. Define and give an example (this can be a scenario) for the following vocabulary; Also, identify them as scalar or vector by writing ‘s’ or ‘v’ to the left of the quantities.

(a) Displacement (denoted as  in the equations) :

(b) Acceleration (denoted as  in the equations):

(c) Average speed (usually not denoted by any special symbol – ‘ave. sp’ will do):

(d) Average velocity (denoted by ):

(e) Instantaneous velocity (denoted by ):

**Vector quantities require a coordinate system with a positive and negative sense of direction in order to describe them. We will use right (positive), left (negative), up (positive) and down (negative) sign convention. The zero of the coordinate system is entirely arbitrary.**

2. (a) Can an object (point particle) traveling in the positive direction have a negative acceleration? Give an example if your answer is yes.

(b) What happens to the **instantaneous speed** of a point particle if it has the following signs for velocity and acceleration? Give both the ‘short time horizon’, i.e., immediately afterwards, and the ‘long time horizon’, i.e., after sufficient time has elapsed, answers. Your answers will state ‘speeding up’, ‘slowing down’ etc.

(i) velocity (-) and acceleration (+)

(ii) velocity (-) and acceleration (-)

(iii) velocity (+) and acceleration (+)

SOLVE THE FOLLOWING PROBLEMS SHOWING ALL STEPS – an answer shouldn’t ‘magically’ appear in the space provided below. Mention which equation was used to arrive at the answer (label the first three equations in the equation sheet 1, 2 and 3)

3. A person goes out for a bike ride along a straight bike path to a nearby town. A record of the trip is as follows: 30 minutes at 30 km/hour, 15 minutes at 40 km/h, 5 minutes at 0 km/h for a break, and 20 minutes at 15 km/h.

(a). What is the distance the person traveled?

(b).What is the average velocity?

4. Train A starts at 4 miles South of a bridge and heads North at a constant speed of 30 miles per hour. Train B starts 6 miles North of the bridge.

(a). What velocity must Train B have so that the two trains cross the bridge at the same time? Ignore the length of the trains.

(b). If Train B goes at 35 miles per hour, South, how far away from the bridge do they cross?

5. A motorcycle is moving at 30m/s when the rider applies the brakes, giving the motorcycle a constant negative acceleration. During the 3.0s interval immediately after braking begins, the speed decreases uniformly to 15m/s.

(a) What is the acceleration of the motorcycle?

(b) How long does the motorcycle take to come to rest after braking begins?

(c) What distance does the motorcycle travel from the instant braking begins until it comes to rest?

6. The driver of a car slams on the brakes when he sees a tree blocking the road. The car slows down uniformly with an acceleration of -5.60 m/s2 for 4.20 s, making straight skid marks 62.4 m long ending at the tree.

* 1. What is the speed of the car when the driver slams on the brakes?

(b) What is the speed of the car when it crashes into the tree?

7. At the instant the traffic light turns green at an intersection, a car starts from rest with a constant acceleration of 2.2 m/s2. At the same instant, a truck, traveling with a constant speed of 9.5 m/s, overtakes and passes the automobile.

(a) Taking t = 0 at the instant the truck passes the car, at what later time does the car overtake the truck? (Hint: objects catch up or overtake when they have the same final position at the same instant)

(b) How far beyond the traffic signal will the car overtake the truck?

(c) How fast will the car be traveling at that instant?

(d) Draw position time graphs qualitatively for the car (solid line) and the truck (dotted line) on the same graph and identify the point found in (a)

(e) Now suppose that while all the quantities are the same for the car and the truck, the car takes off from the intersection 1 second after the truck leaves. When does the car catch up with the truck?

8. A Porsche challenges a Honda to a 400 m race on a straight track. Since the Porsche’s acceleration of 3.5 m/s2 is greater than the Honda’s 3.0 m/s2, the Honda gets a 50 m head start. Both cars start accelerating at the same instant. Who wins?



9. A train is moving towards a destroyed bridge. The velocity of the train remains constant at 20m/s. A person inside the train realizes that he will die unless he runs to the back of the train and jumps out. If the person is 15m from the back of the train and the back of the train is 50m from the break in the track, with what velocity must the person run with respect to the ground to make it to the back of the train just as the back of the train goes over the break in the bridge?

10. After a road trip from Boston to NYC, distance 240 miles, you realize exactly half of the time you were driving 65 miles per hour and the other half at 10 miles per hour in an NYC traffic jam.

(a). What total time did you take to complete the journey? What was your average speed?

(b). What if you were traveling at each speed for half of the **distance** instead of half of the time... What total time did you take now to complete the journey? What is your average speed for the trip?

11. A car starts from rest and travels for 10 seconds with a constant acceleration of 3m/s2. The driver then applies the brakes causing a constant negative acceleration of 4m/s2. Assuming the brakes are applied for 2.0 seconds:

(a). How fast is the car going at the end of braking?

* 1. How far has the car traveled at the end of braking?

ACCELERATION DUE TO GRAVITY is taken to be 10 m/s2 DOWNWARDS. Remember, acceleration is a vector!

12. Rumor has it, that upon the building's completion, a certain physics faculty member contributed significantly to our understanding of gravitation and its effects on large fruit by dropping a watermelon off Wheeler House’s top floor. Given that it took 1.414 seconds before it impacted the floor, from how far off the ground was it dropped?

13. A cannonball is shot straight up from the ground with an initial velocity of 100 m/s.

(a) How high does it go? (Hint: what is its speed at the highest point?)

(b) How long does it take to reach the highest point?

(c) What is its velocity as it reaches the ground? (Hint: what is the displacement of the cannonball when it reaches the ground?)

(d) How long does it take to travel the first 50 m while going up?

(e) What is its velocity at the end of the first 50m?

(f) How long does it take to travel the next 50 m?

14. Heather and Jerry are standing on a bridge 50 m above a river. Heather throws a rock straight down with a speed of 20m/s and Jerry, at the exact moment, throws a rock straight up with a speed of 20m/s. (a) How much time elapses between the first splash and the second splash? (b) Which rock has the faster speed as it hits the water? What are the speeds?

GRAPHICAL ANALYSIS at a glance (OR How to read graphs?):

**Position-time graphs**: position along y and time along x axes

* straight line parallel to time axis = object standing still
* sloped straight line = constant velocity
* curved line = object accelerating
* slope gives velocity – if slope is positive, velocity is positive and vice versa. Steeper slope = greater speed.
* Curve that looks like an upward facing parabola (or part of an upward facing parabola) = positive acceleration; Curve that looks like a downward facing parabola (or part of a downward facing parabola) = positive acceleration
* REMEMBER: positive acceleration DOES NOT always mean speeding up. It only means that the velocity is increasing and velocity being a vector quantity has direction (sign). Initial Velocity of -3 m/s is smaller than final velocity of -1 m/s however initial speed of 3 m/s is great than the final speed of 1 m/s. In this case the acceleration is + while the object slows down.
* SIMPLE RULE: Object speeds up if both velocity and acceleration have same sign - both + or both –

Object slows down if velocity and acceleration have opposite signs

**Velocity-time graphs**: velocity along y and time along x axes

* straight line parallel to time axis = object moving at constant velocity; velocity positive if graph in 1st quadrant – velocity negative if graph in 4th quadrant
* sloped straight line = constant acceleration
* curved line = acceleration changing
* slope gives acceleration – if slope is positive, acceleration is positive and vice versa. Steeper slope = greater magnitude of acceleration.
* REMEMBER THE SIMPLE RULE: Object speeds up if both velocity and acceleration have same sign - both + or both –

Object slows down if velocity and acceleration have opposite signs

**This part of the H.W will NOT be on the first test you take**. This part of the H.W is intended to remind you of some of the concepts you learned in Freshman Physics as well as some upcoming mathematical pre-requisites. You may look up the background Physics online. The Math problems are about figuring things out.

15. In analyzing certain situations, it turns out that the commonly used horizontal (x) – vertical (y) coordinate system becomes cumbersome or makes the analysis more complicated. A slanted/rotated coordinate system becomes more suitable in such situations. One such coordinate system is shown below and a vector in that coordinate system is drawn. Find the components of the vector (line with arrow) in the new coordinate system (dashed lines). Note that the new x –y axes are also perpendicular to each other just as the horizontal (x) – vertical (y)axes were perpendicular to each other.

New x axis

New y axis

Vector of length 100

37°

37°

New y axis

60°

16. The same argument as above; Find the components of the vector (line with arrow) in the new coordinate system (dashed lines).

New x axis

Vector of length 100

**Newton’s 2nd Law**: 

The  in the equation above refers to the vector sum of forces acting on an object. Sometimes is zero as evidenced by the fact that the object appears stationary. In such cases, the law helps us find unknown forces (here trigonometry becomes a very helpful tool). Use this concept to figure out the following problem.

17. A group of students are planning on hanging a sign advertising the new school play. They paint the sign on a rectangular MDF plank that has a mass of 10kg and attach an eyehook at the top so that ropes can be tied to it. They plan on hanging the sign as shown. The downward force is 100N. What is the tension in the ropes if they both make the angles shown in the diagram?

(Hint: Tension points along the ropes. What is balancing the downward 100N?)

The Marriage of Bette and Boo!!

30°

30°

***Fun Fact***: You could never hang the sign with the horizontal ropes!!

**Conservation of Mechanical Energy**: The sum of kinetic energy and Potential energy in a system where friction and applied forces can be ignored, remains constant i.e is *conserved*.

where *vi* and *hi* are the initial height and *vf* and *hf* are the final velocity and height, m is the mass of the object

18. A roller coaster ride at an amusement park starts at A and goes around the loop-the-loop of radius R = 4.9 m. When it is at the top of the loop, point B, it has a speed of 7m/s. Assuming that the ride starts at rest at point A, and no energy is lost to friction or other forces, find h.

***Fun Fact***: An object in circular motion **can not** have a speed of zero at the top of the circle – in fact there exists a minimum speed that the object has to have at the top in order for it to stay in the circular path. Watch: http://www.youtube.com/watch?v=wiZoVAZGgsw

**Conservation of Linear Momentum**: The vector sum of the linear momenta of an interacting system remains constant in the absence of external forces i.e total momentum is *conserved*. This principle is used often in analyzing collisions.

. *i* and *f* refer to before and after collision values, *v* stands for velocity, *m* for mass of colliding objects, 1 and 2 refer to the two objects colliding. Sometimes, objects stick together after collision and move together as one i.e *v1f*= *v2f*.

19. Ryan from the science team has rigged a NERF gun so that it fires darts really fast. In order to find the new improved speed of the darts shot from the modified NERF gun, he shoots the darts onto a wooden block. The Velcro-tipped NERF dart shot from the gun sticks to a wooden block and the block’s speed is measured. The block has a mass of 0.100 kg, the dart’s mass is 0.020 kg and the block is seen to be moving at 2m/s after the collision.

(a) What was the dart’s speed if the block was initially at rest?

(b) The Kinetic Energy (measured in Joules ) of an object can be found using the formula . What was the initial Kinetic Energy of the dart? What was the final kinetic energy of the block + dart?

***Fun Fact***: In collisions, momentum is always conserved but kinetic energy may not be conserved.