Name:____________________________
Section:___________________________

Worksheet #3: One-Dimensional Kinematics

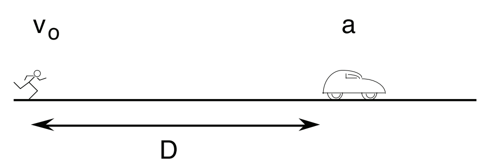
1. Can an object have zero velocity and still be accelerating? To illustrate, consider a pencil tossed straight up into the air.

   (a) Sketch the pencil's acceleration, velocity, and position as functions of time on graphs stacked one above the next. (Many people find it easiest to start with velocity vs time.) Check: do your graphs exhibit the right behavior? For instance, is the slope of the y vs. t graph shown by the velocity curve? Is the slope of the v vs. t curve shown by the acceleration curve?
   (b) On each graph, mark along the t-axis the moment when the pencil is at the top of its trajectory. What do the graphs tell you about the pencil's acceleration at that instant?

2. A diver stands on a platform located $h = 5$ m above the surface of the pool. To begin her dive, she jumps vertically upwards with a speed $v_o = 2$ m/s. After coming back down, she enters the water and decelerates at a rate of 30 m/s^2.

   (a) Sketch y vs t, v_y vs t, and a_y vs t graphs for her entire motion. Mark T_1 as the time when she reaches her greatest height above the pool surface, and T_2 as the time when she strikes the water.
   (b) Find the greatest height she reaches above the pool surface.
   (c) Find the velocity with which she strikes the water.
   (d) After entering the water, over what distance will she come to rest?

3. In an old television show called "The Six Million Dollar Man," Colonel Steve Austin had superhuman abilities; for one thing, he could run faster than normal humans do. In one episode, Steve Austin tries to catch a villain who is fleeing in a sports car. The sports car accelerates from rest at a constant rate of $a = 5$ m/s^2. Steve Austin, who is initially a distance $D = 100$ m behind the sports car, runs to catch it at a constant speed v_o. (Assume that he reaches this top speed right away.)



   (a) On a single position versus time graph, sketch the positions of both the car and Steve Austin as functions of time.
   (b) In part (a), you sketched the position of Steve Austin as a function of time. But naturally the *specific* appearance of his position versus time graph will depend on the *numerical value* of his speed v_o, which was not given. To get an idea of the various possibilities, sketch on your original position versus time graph what Steve Austin's position versus time would look like, if he were going *faster* than when you drew it

originally. Then, again on your original graph, sketch what his position versus time would look like if he were going *slower* than when you drew it originally.

(c) Now suppose $v_o = 30$ m/s. If Steve Austin will catch the car, find the time at which this happens. Otherwise, find the distance of his nearest approach to the car.

4. Rob and Dave run a 100–m race, crossing the finish line in a dead heat, both taking 10.0 s. They each accelerate uniformly, but Rob takes 2.00 s to reach his maximum speed, while Dave takes 3.00 s. Each maintains his maximum speed for the rest of the race.

   (a) On a single graph, sketch velocity versus time curves for Rob and Dave. Try to get as many features as correct as you can. (For instance, both curves should start and end at the same time. How do the areas under the two curves compare?)
   (b) Find the acceleration of each runner.
   (c) What are their respective maximum speeds?
   (d) Which sprinter is ahead after 6.00 s? By how much?

5. A model rocket is fired vertically and ascends with a constant vertical acceleration of 4.0 m/s^2 for 6.0 s. Its fuel then runs out, and it continues in free fall.

   (a) Sketch y vs t, v_y vs t, and a_y vs t graphs for the entire motion. Mark T_1 as the time when the rocket runs out of fuel, T_2 as the time when it reaches its maximum height, and T_3 as the time it strikes the earth.
   (b) Find the maximum height that the rocket reaches.
   (c) Find the total time that the rocket spends in the air.
   (d) Find the velocity with which the rocket hits the ground.

6. A probe has been launched vertically from the surface of Mars. At time $t = 0$, it has reached a height of $y_{1,0} = 320$ m, and is moving upward at $v_{1,0} = 80$ m/s when its engines cut out. At the same moment, the mother ship is $y_{2,0} = 1500$ m from the Martian surface, moving down directly toward the probe at 25 m/s and slowing down at the rate of 0.80 m/s^2. On the surface of Mars, the gravitational acceleration is $g = 3.72$ m/s^2. (The probe is Object #1, and the ship is Object #2.)
   (a) Sketch graphs (y vs. t, v vs. t, and a_y vs. t) for the motion of the probe and the ship, putting both objects' motion on each graph. Align your graphs vertically so that the horizontal (time) axes are all the same.
   (b) When will the ship reach the probe?
   (c) How high above the surface of Mars will the first rendezvous occurs?
   (d) Find the velocities (including ± directions) at the first rendezvous.

7. A crane lifts a load of bricks at a steady velocity v_0 = 5.0 m/s. At time t = 0, a single brick falls off a distance h = 6.0 m above the ground.

   Sketch y vs t, v vs t, and a vs t graphs to show the motion of the brick for $t \geq 0$.

   (a) In terms of the symbols given, what is the greatest height the brick reaches above the ground?

   (b) In terms of the symbols given, how long does it take for the brick to reach the ground?

   (c) In terms of the symbols given, what is its speed just before it hits the ground?

   (d) *Now e*valuate your answers to parts (b), (c), and (d) with numerical values. Show units in all intermediate calculations. Round final answers to 3 significant figures.