Circle the letter of the single best answer. Each question is worth 1 point

Physical Constants:

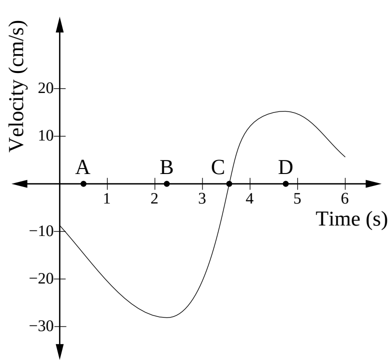
Earth's free-fall acceleration $= g = 9.80$ m/s^2

1. The velocity, v, of a certain particle is given by the equation:
$$v = ae^{bt}$$
where t is the time. The dimensions of a and b are respectively:
   A. L, T
   B. L/T, T
   C. L, $1/T$
   D. L/T, $1/T$

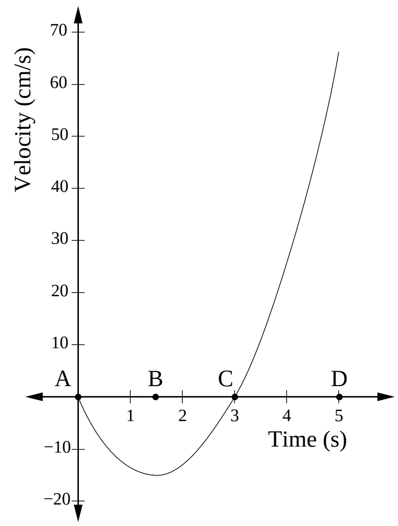
2. How many of the below numbers display exactly 3 significant digits?
   - .009
   - 700
   - 0.72
   - 5.20
   - 2002.1
   - 0.720

   A. one
   B. two
   C. three
   D. none of the above

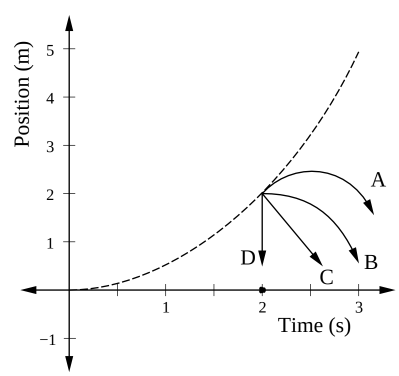
3. The below graph displays the velocity, v, of an object as a function of time. Circle the labeled time when the particle has the maximum acceleration. (Note: negative numbers are smaller than any positive number.)



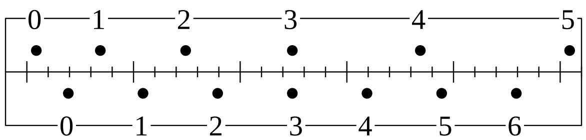
4. The below graph displays the velocity, v, of an object as a function of time. Circle the labeled time when the particle has moved its furtherest to the left.



5. Starting from rest, an elevator goes upward. The dashed curve shows the position of the elevator ceiling as a function of time. At $t = 2$ s, a screw on the ceiling comes loose and drops to the floor of the elevator. Which curve best represents the position of the screw as a function of time?



6. A “two-lane” version of the sparker used in lab 2 locates the position of two different objects at times equal to whole number of winks. (Recall: a wink is 1/60 second.) On the below tape, each spark dot is labeled with the actual time in winks that the object was at that location. At what time do the objects have the same velocity?



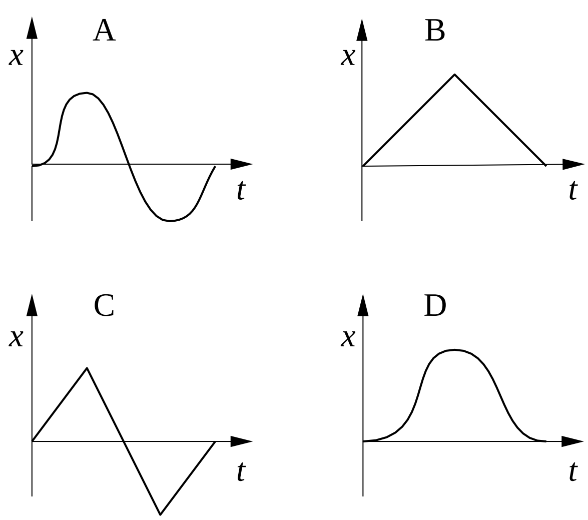
A. $t = 1$ winks

B. $t = 2$ winks

C. $t = 3$ winks

D. $t = 4$ winks

7. Starting from rest, a car accelerates down a straight road. A short time later the driver, realizing he’s left something behind, applies the brakes, comes to a stop and immediately puts the car in reverse and returns to the original spot and again stops. Which of the below graphs of position vs. time best displays this motion?



8. Below is displayed a vector $\vec{A} = \langle A_x, A_y \rangle$. Note that $A_x < 0$ and $A_y > 0$ and that angle θ is between 90° and 180°. Which combination of the below statements is correct? (Note: on some calculators the function “$\tan^{-1}$” will be called “arctan” or “atan”; same story for “$\cos^{-1}$”.)

I. $\tan\theta = A_y/A_x$

II. $\cos\theta = A_x/|\vec{A}|$

III. $\theta = \tan^{-1}(A_y/A_x)$

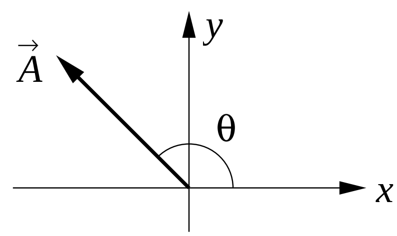
IV. $\theta = \cos^{-1}\left(A_x/|\vec{A}|\right)$

A. I, III

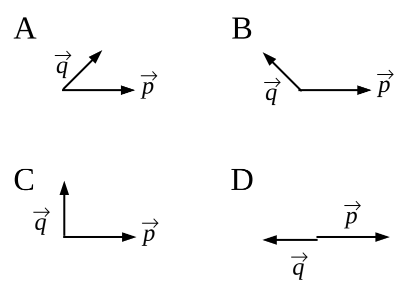
B. I, II, III, IV

C. I, II, IV

D. none of the above



9. The below displays the vectors $\vec{p}$ and $\vec{q}$ in various orientations. The vectors always have the same length, only the orientation is changing. Circle the case in which $\vec{p} \times \vec{q}$ has a maximum magnitude.



10. Below is displayed the path of two equally high football kicks made on an air-less planet. The initial velocity of kick one is $\vec{v}_1 = \langle v_{1x}, v_{1y} \rangle$; The initial velocity of kick two is $\vec{v}_2 = \langle v_{2x}, v_{2y} \rangle$. Which combination of the below statements is correct?

    I. $|\vec{v}_1| = |\vec{v}_2|$

    II. $v_{1x} = v_{2x}$

    III. $v_{1y} = v_{2y}$

    IV. $v_{1x} < v_{2x}$

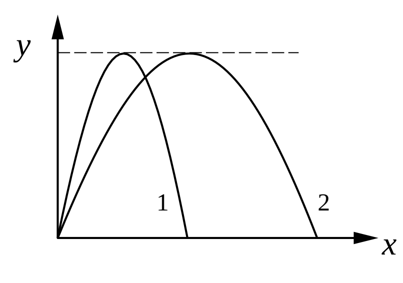
    V. $v_{1y} < v_{2y}$

    A. I, III

    B. II, V

    C. III, IV

    D. I, IV



11. Of the following situations, which one is impossible?

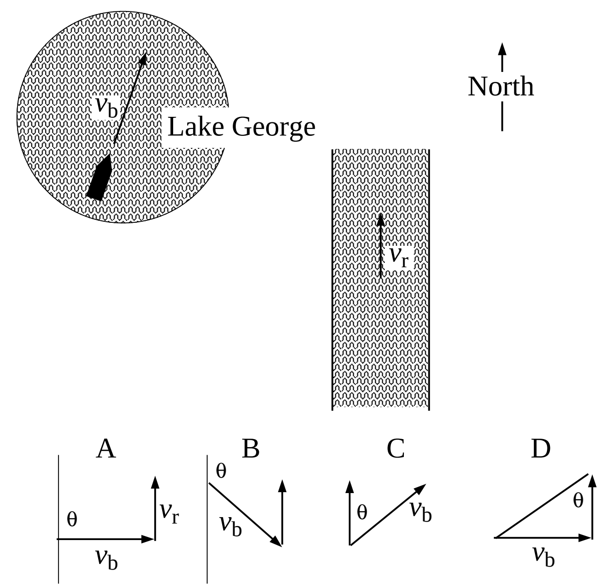
    A. A body has a constant velocity and a variable acceleration.

    B. A body has a constant speed and a variable acceleration.

    C. A body has a variable speed and a constant acceleration.

    D. More than one of the above is impossible.

12. The rivers on planet Sar flow swiftly, and Twen is himself in a great hurry: strange giant amphibians are pursuing him and he must cross the great river (from west to east) *in the least possible time.* Twen is able to paddle his yatch (a small boat) in any direction at a speed v_b on nearby "Lake George". But while Lake George is still, the great river flows due north at a speed v_r. Which of the below vector diagrams properly shows the angle θ relative to north at which he should aim his yatch?



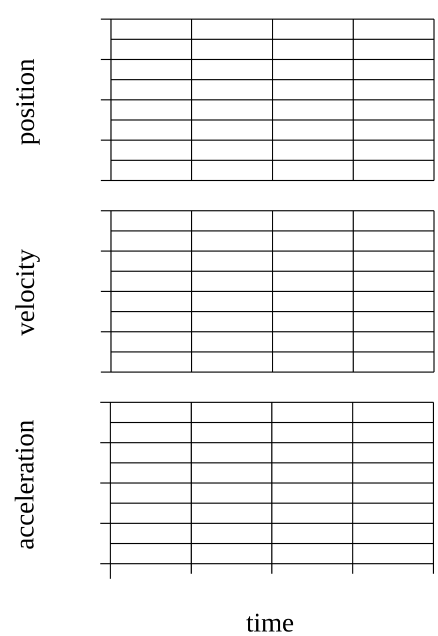
The following questions are worth 5 pts each

13. Consider a coordinate system in which the $\hat{\jmath}$ direction points due north and the $\hat{\imath}$ direction points due east. The following vectors are given:

$$\begin{aligned}\vec{a} &= (-4\text{ km})\,\hat{\imath} + (1\text{ km})\,\hat{\jmath} \\ \vec{b} &= (-2\text{ km})\,\hat{\imath} + (-3\text{ km})\,\hat{\jmath} \\ \vec{c} &: \quad 13\text{ km in a direction } 22.6^\circ \text{ north of east}\end{aligned}$$

Sketch each vector and display how the arrows can be arranged to find the sum of the three vectors. Resolve $\vec{c}$ into components and calculate the sum of all three vectors. Express the sum as a magnitude and direction.

14. You throw a ball straight up 20 m, and then catch it exactly where you released it. Use the below graph paper to sketch three graphs of the entire up-and-back motion: position (height) vs. time, velocity vs. time, and acceleration vs. time. Note that the supplied grids lack scales! You will need to calculate some typical values in order to make proper scales for your graph. I suggest finding the total time of flight, and the maximum velocity during the flight, but feel free to calculate anything that will provide accurate values for your scales. As usual, make a drawing of the scene displaying the origin and direction of the axis you're using for position. Just to make graphing easy, you can use $g = 10\text{ m/s}^2$ for this problem.



15. The aliens on the planet Tar are interested in increasing the size of their frog population. Genetic manipulation seems to be the answer, and the first step is gene isolation and sequencing. Since the scientific gear of Tar is substandard, they have purchased on ebay an "Acme Ultra Centrifuge" (they got a great price, but the shipping and handling killed them). They were puzzled by the name "centrifuge", since even a (Tarian) child knows the spinning device works by centripetal acceleration. (But things on Earth are often strange and inexplicable.) In any case the device came without a manual and given that conversion of alien units often seems difficult, they abducted a biochem major from Physics 191 to run the machine (or die). The instructions say: "spin-down" the genetic material at 1 Mega g. The radius of the rotor is 10 cm. The centrifuge dial is in the strange Earth units of "rpm". What setting of the centrifuge rpm dial will please the Tarians?

16. If interstellar spacecraft engines ran without fuel (a rather unlikely "if"), the obvious strategy would be to travel half the distance to the star with a positive acceleration of g, and then use the remaining half to de-accelerate at g. We know that there are planets around 16 Cyg B, a star similar to the Sun. This star is 21.41 pc away from us. (Recall: 1 pc $= 3.0857 \times 10^{16}$ m.) How long would it take to get to 16 Cyg B, using this obvious strategy. (Express your result in years.)

17. You may recall that on the planet Sar they play a game in which physicists abducted from neighboring planets play a brief but important role. The physics-loving natives of the planet Tar have vowed vengeance for this outrage! As you read this Tarian spaceships are bombarding the surface of Sar with weapons of mass destruction: massive killer frogs. (Recall that the physicists were abducted.) Most of the mass "destroyed" is frog, as they only rarely survive the fall. The below stroboscopic picture shows a few exciting cens in the life of one such frog. (As usual, on Sar, distances are measured in tf and time in cen.) Please determine when this frog "bites the dust"...clearly just a bit more than $t = 3$ cen. As part of the process you'll probably also want to find v_{0y} and Sar's g.