APPC, Mechanics: Unit α HW 1

Name: ______________________________
Hr: ___ Due at beg of hr on: __________

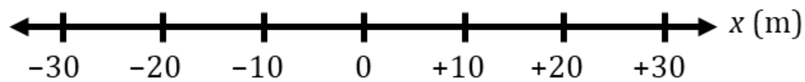
Uα, HW1, P1
Reference Video: "Distance, Position, Displacement, Velocity, and Acceleration"
YouTube, lasseviren1

A. Define the following. i. kinematics ii. dynamics

B. For what quantities does the narrator use the following variables?
i. x
ii. Δx
iii. d

C. What one-letter variable does the narrator use for the following quantities?
i. speed
ii. velocity
iii. acceleration

Now consider the number line at right.



D. If an object starts at x = +30 m, goes to x = −30 m, and then finally ends at x = −10 m, determine the:
i. distance
ii. displacement

E. If the motion of Part D occurs over a time interval of 8 s, determine the:
i. average speed
ii. average velocity

F. Circle the correct answers.

i. acceleration	is always (+)	is always (−)	could be (+) or (−)
ii. speed	is always (+)	is always (−)	could be (+) or (−)
iii. distance	is always (+)	is always (−)	could be (+) or (−)
iv. position	is always (+)	is always (−)	could be (+) or (−)
v. velocity	is always (+)	is always (−)	could be (+) or (−)
vi. displacement	is always (+)	is always (−)	could be (+) or (−)

G. Give a very brief explanation that justifies ALL of your Part F answers.

H. Write the complete equation definitions for the quantities at right. HINTS: Besides the "=" sign already shown, each of your equation definitions should include ANOTHER "=" sign, a limit, as well as the proper differentials.

i. instantaneous velocity $\vec{v} =$

ii. instantaneous acceleration $\vec{a} =$

Uα, HW1, P2
Reference Video: "Relative Velocity"
YouTube, lasseviren1, KINEMATICS playlist

A. Write out, in words, what is meant by the designation: $\vec{v}_{XY}$

B. Write out, in words, what is meant by the designation: $\vec{v}_{YX}$

C. Write TWO equations that relate the designations in Parts A and B to each other. ______________ AND ______________

Suppose you are given the following velocity vectors: $\vec{v}_{AJ}$ and $\vec{v}_{WH}$ and $\vec{v}_{JW}$

D. Write out the equation for finding $\vec{v}_{AH}$.

E. Write out the most-straightforward equation for finding $\vec{v}_{HJ}$, i.e., do NOT use any (−) signs in this answer.

F. Modify <u>the right side</u> of your Part E answer such that all variables are given varibles. HINT: This answer is related to your Part C answer, and you will now need to use one or more (−) signs.

G. A swimmer's path relative to the Earth is directly across a river at 1.7 m/s north. The current flows at 2.1 m/s east. Your task is to find the velocity of the swimmer relative to the current, in this way:

i. Choose appropriate variables and write the most-straightforward equation for finding your answer, similar to what you did in your Part E answer.

ii. Look at the two terms on the right side of your Part Gi answer. You should be able to see that the given information provides ONE of them, but gives the OPPOSITE of the other. Similar to what you did in your Part F answer, rewrite the right side of your Part Gi answer so that it has ONLY given quantities.

iii. Now, make a crude sketch showing that you know how to "add" the vectors on the right side of your Part Gii answer. Label each of those two vectors and show their magnitudes. Show also (and label) the vector from the left side of your Part Gii answer, but DO NOT yet show its magnitude or direction. In essence, you will be drawing and labeling a right triangle.

iv. Now, finally, use your calculator to determine the magnitude and direction of the vector requested at the start of this problem.

Now, use the skills you've practiced here to solve the following problem.

H. A plane directed due west with a velocity of 240 km/h relative to the air encounters a wind going 65 km/h at 35^{o} north of west, relative to the Earth. Find the velocity of the plane relative to the Earth.

Uα, HW1, P3

Reference Videos: (1) "Relative Velocity"
(2) "Deriving Kinematics Equations Using a Velocity vs. Time Graph"
YouTube, lasseviren1

We first continue using skills you learned and practiced in the previous assignment.

A. A boat moves to the east at 5.2 m/s, relative to a flowing river (NOT relative to the Earth!). The river flows due south at 3.8 m/s. (It might help to draw a sketch in the space at right.)

i. Find the velocity of the boat relative to the shore.

ii. If the river is a constant 85 m wide, find the time required for the boat to cross it.

iii. Find the distance downstream the boat will have drifted by the time it reaches the opposite shore.

B. An aircraft carrier has a heading of 35° north of east, poking along at 7.5 m/s, relative to the ocean's current. The current is flowing 2.8 m/s north, relative to a nearby land mass. A sailor walks across the deck of the ship at 2.3 m/s, in the direction 45° west of north. Find the velocity of the sailor relative to the land mass.

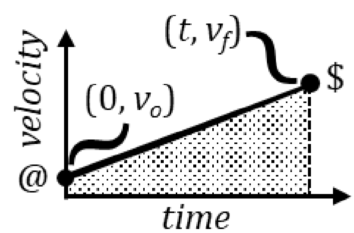
There are four kinematics equations, for cases of constant acceleration.

I. $v_f = v_o + at$

II. $\Delta x = \frac{1}{2}(v_f + v_o)t$

III. $\Delta x = v_o t + \frac{1}{2}at^2$

IV. $v_f^2 = v_o^2 + 2a\Delta x$



Here, you will derive the first two equations, starting from the graph shown.

D. Firstly, what feature of the graph indicates constant (or uniform, same thing) acceleration?

E. Write the general equation for slope-intercept form; you learned this in first-year algebra.

F. From the graph, what is the value of the *y*-intercept?

G. Substitute the coordinates of Point $ into your Part E answer for *x* and *y* to derive Equation I above.

H. What physical quantity is indicated by the shaded area under the graph above?

I. For the trapezoid shown in the graph, the area can be found by taking the ________________ of the lengths of the parallel edges and multiplying by the trapezoid's __________.

J. Use your Parts H and I answers to derive Equation II above.

Uα, HW1, P4

Reference Videos: (1) "Deriving Kinematics Equations Using a Velocity vs. Time Graph"
(2) "A Fast and Intuitive Method for Solving Some Kinematics Problems"
YouTube, lasseviren1

Here, we first finish deriving Kinematics Equations III and IV, so you will need to refer back to P3.

In P3, Parts H-J, you used the area of the entire trapezoid to derive Equation II. Let's use area again, but this time we'll break the trapezoid's area into two parts, a rectangle and a triangle.

A. Using variables from the graph: Write the expression for the rectangle's area, including some sort of designation for the proper physical quantity on the equation's left side.

B. Write the expression for the triangle's area. Again, include some sort of designation for the proper physical quantity on the equation's left side.

C. There should be a term inside ( ) in your Part B answer. Refer back now to your answer to Part G of P3. Use that Part G answer to modify your Part B answer so as to get rid of the ( ).

D. Combine your Parts A and C answers to derive Equation III.

E. Lastly, we derive Equation IV. Begin by solving Equation I for t.

F. Substitute your Part E answer into Equation II. Show the process; DON'T simplify it yet.

G. Now, simplify your Part F answer to derive Equation IV.

We now solve a few kinematics problems intuitively. Such problems MUST have objects undergoing uniform acceleration, and must involve fairly simple numbers. For Parts H-K, DO NOT use a calculator.

H. Based on the given $\boldsymbol{v_o}$ and $\boldsymbol{a}$, determine the object's velocity at each second for the next FIVE seconds.

i. $\boldsymbol{v_o}$ = +3 m/s, $\boldsymbol{a}$ = +2 m/s^2 $\boldsymbol{v}_{1\,\mathrm{s}}$ = $\boldsymbol{v}_{2\,\mathrm{s}}$ = $\boldsymbol{v}_{3\,\mathrm{s}}$ = $\boldsymbol{v}_{4\,\mathrm{s}}$ = $\boldsymbol{v}_{5\,\mathrm{s}}$ =

ii. $\boldsymbol{v_o}$ = +10 m/s, $\boldsymbol{a}$ = −4 m/s^2 $\boldsymbol{v}_{1\,\mathrm{s}}$ = $\boldsymbol{v}_{2\,\mathrm{s}}$ = $\boldsymbol{v}_{3\,\mathrm{s}}$ = $\boldsymbol{v}_{4\,\mathrm{s}}$ = $\boldsymbol{v}_{5\,\mathrm{s}}$ =

I. Without using a calculator, determine the displacement for each set of given information.

i. $\boldsymbol{v_o}$ = 0 m/s, $\boldsymbol{a}$ = +5 m/s^2, t = 4 s $\Delta\boldsymbol{x}$ =

ii. $\boldsymbol{v_o}$ = +4 m/s, $\boldsymbol{a}$ = +2 m/s^2, t = 5 s $\Delta\boldsymbol{x}$ =

iii. $\boldsymbol{v_o}$ = −10 m/s, $\boldsymbol{a}$ = −5 m/s^2, t = 4 s $\Delta\boldsymbol{x}$ =

iv. $\boldsymbol{v_o}$ = −24 m/s, $\boldsymbol{a}$ = +8 m/s^2, t = 5 s $\Delta\boldsymbol{x}$ =

J. How far will this object travel before coming to rest? $\boldsymbol{v_o}$ = +24 m/s, $\boldsymbol{a}$ = −4 m/s^2

K. To TWO sig figs, **estimate** $\Delta\boldsymbol{x}$. $\boldsymbol{v_o}$ = +8.16 m/s, $\boldsymbol{a}$ = +2.93 m/s^2, t = 4.14 s $\Delta\boldsymbol{x}$ =

Uα, HW1, P5

Reference Videos: (1) "A Fast and Intuitive Method for Free Fall Problems"
(2) "Derivatives and Antiderivatives, Part 1"
YouTube, lasseviren1

Here, we first tackle solving one-dimensional free-fall problems intuitively, without a calculator.

A. To do this, what two assumptions must we make (on Earth)?
i.
ii.

B. Based on your Part A answers:
i. When an object is traveling upward, it…
ii. When an object is traveling downward, it…

C. Without using a calculator, solve the following problems. Assume that the object is launched or released from whatever elevation is necessary to make the given conditions conform to your answers of Part B, e.g., launched from the ground, or launched upward or downward from the edge of a cliff. Ignore sig figs; just follow the example shown in the video.

i. $\boldsymbol{v_o}$ = 0 m/s, t = 4 s $\Delta\boldsymbol{y}$ =

ii. $\boldsymbol{v_o}$ = –10 m/s, t = 4 s $\Delta\boldsymbol{y}$ =

iii. $\boldsymbol{v_o}$ = +10 m/s, t = 5 s $\Delta\boldsymbol{y}$ =

iv. $\boldsymbol{v_o}$ = 0 m/s, t = 2 s $\Delta\boldsymbol{y}$ =

v. $\boldsymbol{v_o}$ = +65 m/s, t = 3 s $\Delta\boldsymbol{y}$ =

vi. $\boldsymbol{v_o}$ = +35 m/s, t = 8 s $\Delta\boldsymbol{y}$ =

vii. $\boldsymbol{v_o}$ = –15 m/s, t = 7 s $\Delta\boldsymbol{y}$ =

viii. $\boldsymbol{v_o}$ = +75 m/s, t = 5 s $\Delta\boldsymbol{y}$ =

D. If launched from the ground, to what height will this object climb? $\boldsymbol{v_o}$ = +80 m/s

E. To the nearest 0.1 s, estimate the time for this object to reach the top. $\boldsymbol{v_o}$ = +43 m/s

F. To the nearest 0.1 s, estimate the time for the Part E object to return to its point of launch.

G. To TWO sig figs, **<u>estimate</u>** $\Delta\boldsymbol{y}$. Do NOT use a calculator.

i. $\boldsymbol{v_o}$ = +38.6 m/s, t = 2.11 s $\Delta\boldsymbol{y}$ =

ii. $\boldsymbol{v_o}$ = 0 m/s, t = 7.81 s $\Delta\boldsymbol{y}$ =

iii. $\boldsymbol{v_o}$ = +27.2 m/s, t = 5.21 s $\Delta\boldsymbol{y}$ =

iv. $\boldsymbol{v_o}$ = –19.4 m/s, t = 8.31 s $\Delta\boldsymbol{y}$ =

The last part of this assignment relates to the video, "Derivatives and Antiderivatives, Part 1".

H. A derivative of a function is related to WHAT FEATURE of a graph of that function?

I. We are going to forgo the full treatment of using the definition of the derivative to find said derivative. Instead, we will just apply the two steps that the narrator gives for differentiating polynomials. In words, list those two steps, at right.
i.
ii.

J. Determine the derivative of each function.

i. $x(t) = 3t^4$ $\frac{dx}{dt} =$

ii. $x(t) = 2t^3$ $\frac{dx}{dt} =$

iii. $v(t) = -4.2t^2$ $\frac{dv}{dt} =$

iv. $v(t) = 5.4t^{-2}$ $\frac{dv}{dt} =$

v. $v(t) = -2t^{-6}$ $\frac{dv}{dt} =$

vi. $x(t) = -6t^{-3}$ $\frac{dx}{dt} =$