Week 2: Chapter 2

Week 2: Chapter 2
Due: 11:59pm on Sunday, February 1, 2015
To understand how points are awarded, read the Grading Policy for this assignment.

Kinematic Vocabulary
Description: A series of questions designed to sharpen the understanding of terms used to describe motion.

One of the difficulties in studying mechanics is that many common words are used with highly specific technical meanings, among them velocity, acceleration, position, speed, and displacement. The series of questions in this problem is designed to get you to try to think of these quantities like a physicist.

Answer the questions in this problem using words from the following list:

A. position
B. direction
C. displacement
D. coordinates
E. velocity
F. acceleration
G. distance
H. magnitude
I. vector
J. scalar
K. components

Part A

Velocity differs from speed in that velocity indicates a particle’s _________ of motion.

Enter the letter from the list given in the problem introduction that best completes the sentence.

ANSWER:

B

Also accepted: direction

Part B

Unlike speed, velocity is a _________ quantity.

Enter the letter from the list given in the problem introduction that best completes the sentence.

ANSWER:

I

Also accepted: vector
Part C

A vector has, by definition, both ________ and direction.

Enter the letter from the list given in the problem introduction that best completes the sentence.

ANSWER:

H

Also accepted: magnitude

Part D

Once you have selected a coordinate system, you can express a two-dimensional vector using a pair of quantities known collectively as ________.

Enter the letter from the list given in the problem introduction that best completes the sentence.

ANSWER:

K

Also accepted: components, D, coordinates

Part E

Speed differs from velocity in the same way that ________ differs from displacement.

Enter the letter from the list given in the problem introduction that best completes the sentence.

Hint 1. Definition of displacement

Displacement is the vector that indicates the difference of two positions (e.g., the final position from the initial position). Being a vector, it is independent of the coordinate system used to describe it (although its vector components depend on the coordinate system).

ANSWER:

G

Also accepted: distance

Part F

Consider a physical situation in which a particle moves from point A to point B. This process is described from two coordinate systems that are identical except that they have different origins.

The ________ of the particle at point A differ(s) as expressed in one coordinate system compared to the other, but the ________ from A to B is/are the same as expressed in both coordinate systems.

Type the letters from the list given in the problem introduction that best complete the sentence. Separate the letters with commas. There is more than one correct answer, but you should only enter one pair of comma-separated letters. For example, if the words "vector" and "scalar" fit best in the blanks, enter I, J.
ANSWER:

Also accepted: position, C, D, C, coordinates, C, A, displacement, position, displacement, D, displacement, coordinates, displacement, A, G, position, G, D, G, coordinates, G, A, distance, position, distance, D, distance, coordinates, distance, A, E, position, E, D, E, coordinates, E, A, velocity, position, velocity, D, velocity, coordinates, velocity, A, B, position, B, D, B, coordinates, B, A, direction, position, direction, D, direction, coordinates, direction

The coordinates of a point will depend on the coordinate system that is chosen, but there are several other quantities that are independent of the choice of origin for a coordinate system: in particular, distance, displacement, direction, and velocity. In working physics problems, unless you are interested in the position of an object or event relative to a specific origin, you can usually choose the coordinate system origin to be wherever is most convenient or intuitive.

Note that the vector indicating a displacement from A to B is usually represented as $\vec{r}_{BA} = \vec{r}_B - \vec{r}_A$.

Part G

Identify the following physical quantities as scalars or vectors.

ANSWER:

Exercise 2.4

**Description:** Starting from a pillar, you run a distance 200 m east (the + x-direction) at an average speed of 5.0 m/s, and then run a distance 280 m west at an average speed of 4.0 m/s to a post. (a) Calculate your average speed from pillar to post. (...)

Starting from a pillar, you run a distance 200 m east (the + x-direction) at an average speed of 5.0 m/s, and then run a distance 280 m west at an average speed of 4.0 m/s to a post.
Part A

Calculate your average speed from pillar to post.

Express your answer using two significant figures.

ANSWER:

\[ v = 4.4 \text{ m/s} \]

Part B

Calculate your average velocity from pillar to post.

Express your answer using two significant figures.

ANSWER:

\[ \dot{v} = -0.73 \text{ m/s} \]

Exercise 2.8

Description: A bird is flying due east. Its distance from a tall building is given by \( x(t) = x_0 + (v_0)t - (a_0)t^3 \). (a)

What is the instantaneous velocity of the bird when \( t = \# \text{ s} \)?

A bird is flying due east. Its distance from a tall building is given by

\[ x(t) = 32.0 \text{ m} + (11.4 \text{ m/s})t - (0.0440 \text{ m/s}^3)t^3 \]

Part A

What is the instantaneous velocity of the bird when \( t = 8.00 \text{ s} \)?

Express your answer with the appropriate units.

ANSWER:

\[ v_x = v - a_0t = 2.95 \frac{\text{m}}{\text{s}} \]

Exercise 2.12

Description: The figure shows the velocity of a solar-powered car as a function of time. The driver accelerates from a stop sign, cruises for 20 s at a constant speed of 60 km/h, and then brakes to come to a stop 40 s after leaving the stop sign. (a) Compute the ...

The figure shows the velocity of a solar-powered car as a function of time. The driver accelerates from a stop sign, cruises for 20 s at a constant speed of 60 km/h, and then brakes to come to a stop 40 s after leaving the stop sign.
Part A
Compute the average acceleration during the time interval \( t = 0 \) to \( t = 10 \text{s} \).
Express your answer using two significant figures.
ANSWER:
\[ a_{av} = 1.7 \text{ m/s}^2 \]

Part B
Compute the average acceleration during the time interval \( t = 30 \text{s} \) to \( t = 40 \text{s} \).
Express your answer using two significant figures.
ANSWER:
\[ a_{av} = -1.7 \text{ m/s}^2 \]

Part C
Compute the average acceleration during the time interval \( t = 10 \text{s} \) to \( t = 30 \text{s} \).
Express your answer using two significant figures.
ANSWER:
\[ a_{av} = 0 \text{ m/s}^2 \]

Part D
Compute the average acceleration during the time interval \( t = 0 \) to \( t = 40 \text{s} \).
Express your answer using two significant figures.
ANSWER:

\[ a_{av} = 0 \text{ m/s}^2 \]

Part E

What is the instantaneous acceleration at \( t = 20s \)?

Express your answer using two significant figures.

ANSWER:

\[ a = 0 \text{ m/s}^2 \]

Part F

What is the instantaneous acceleration at \( t = 35s \)?

Express your answer using two significant figures.

ANSWER:

\[ a = -1.7 \text{ m/s}^2 \]

Exercise 2.18

Description: The position of the front bumper of a test car under microprocessor control is given by \( x(t) = 2.17(\text{ m}) + (4.80(\text{ m/s})^2) t^2 - (0.100(\text{ m/s})^6) t^6 \). (a) Find its position at the first instant when the car has zero velocity. (b) Find its...

The position of the front bumper of a test car under microprocessor control is given by

\[ x(t) = 2.17m + (4.80m/s^2)t^2 - (0.100m/s^6)t^6 \]

Part A

Find its position at the first instant when the car has zero velocity.

ANSWER:

\[ x = 2.17 \text{ m} \]

Part B

Find its acceleration at the first instant when the car has zero velocity.

ANSWER:

\[ a_x = 9.60 \text{ m/s}^2 \]
Part C
Find its position at the second instant when the car has zero velocity.

ANSWER:

\[ x = 15.0 \text{ m} \]

Part D
Find its acceleration at the second instant when the car has zero velocity.

ANSWER:

\[ a_x = -38.4 \text{ m/s}^2 \]

Part E
Draw \(x - t\) graph for the motion of the bumper between \(t = 0\) and \(t = 2.00 \text{ s}\).

ANSWER:

\[ x = -15.0 \text{ m} - 38.4 \text{ m/s}^2 \cdot t \quad \text{for} \quad t = 2.00 \text{ s} \]

Part F
Draw \(v_x - t\) graph for the motion of the bumper between \(t = 0\) and \(t = 2.00 \text{ s}\).

ANSWER:
Part G

Draw $a_x - t$ graph for the motion of the bumper between $t = 0$ and $t = 2.00$ s.

ANSWER:
Exercise 2.19

Description: An antelope moving with constant acceleration covers the distance $x$ between two points in time $t$. Its speed as it passes the second point is $v$. (a) What is its speed at the first point? (b) What is the acceleration?

An antelope moving with constant acceleration covers the distance $70.0 \text{ m}$ between two points in time $7.00 \text{ s}$. Its speed as it passes the second point is $16.0 \text{ m/s}$.

**Part A**

What is its speed at the first point?

ANSWER:

$$v = \frac{2x}{t} - v = 4.00 \text{ m/s}$$

**Part B**

What is the acceleration?

ANSWER:

$$a = 2 \left( \frac{v}{t} - \frac{x}{t^2} \right) = 1.71 \text{ m/s}^2$$

Exercise 2.34

Description: At the instant the traffic light turns green, a car that has been waiting at an intersection starts ahead with a constant acceleration of $a$. At the same instant a truck, traveling with a constant speed of $v$, overtakes and passes the car. (a) How far...

At the instant the traffic light turns green, a car that has been waiting at an intersection starts ahead with a constant acceleration of $3.50 \text{ m/s}^2$. At the same instant a truck, traveling with a constant speed of $23.5 \text{ m/s}$, overtakes and passes the car.

**Part A**

How far beyond its starting point does the car overtake the truck?

ANSWER:

$$d_1 = \frac{2(v^2)}{a} = 316 \text{ m}$$

**Part B**

How fast is the car traveling when it overtakes the truck?

ANSWER:
Exercise 2.40

Description: A lunar lander is making its descent to Moon Base I. The lander descends slowly under the retro-thrust of its descent engine. The engine is cut off when the lander is 5.0 m above the surface and has a downward speed of 0.80 m/s. With the engine off, the lander is in free fall.

A lunar lander is making its descent to Moon Base I. The lander descends slowly under the retro-thrust of its descent engine. The engine is cut off when the lander is 5.0 m above the surface and has a downward speed of 0.80 m/s. With the engine off, the lander is in free fall.

Part A

What is the speed of the lander just before it touches the surface? The acceleration due to gravity on the moon is 1.6 m/s².

Express your answer using two significant figures.

ANSWER:

\[ v = 4.1 \text{ m/s} \]

Exercise 2.52

Description: The acceleration of a bus is given by \( a_x(t) = \alpha t \), where \( \alpha \) is a constant. (a) If the bus's velocity at time \( t_1 \) is \( v_1 \), what is its velocity at time \( t_2 \)? (b) If the bus's position at time \( t_1 \) is \( x_1 \), what is its position at time \( t_2 \)?

The acceleration of a bus is given by \( a_x(t) = \alpha t \), where \( \alpha = 1.24 \text{m/s}^3 \) is a constant.

Part A

If the bus's velocity at time \( t_1 = 1.19 \text{s} \) is 4.92 m/s, what is its velocity at time \( t_2 = 2.20 \text{s} \)?

ANSWER:


\[ v = v_1 + \frac{\alpha (t_2^2 - t_1^2)}{2} = 7.04 \text{ m/s} \]

**Part B**

If the bus's position at time \( t_1 = 1.19 \text{s} \) is 5.93 m, what is its position at time \( t_2 = 2.20 \text{s} \)?

**ANSWER:**

\[ x = \frac{\alpha (t_2^3 - t_1^3)}{6} + \left( v_1 - \frac{\alpha t_1^2}{2} \right) (t_2 - t_1) + x_1 = 11.9 \text{ m} \]

**Problem 2.84**

**Description:** A flowerpot falls off a windowsill and falls past the window below. You may ignore air resistance. It takes the pot 0.420 s to pass from the top to the bottom of this window, which is 1.90 m high. (a) How far is the top of the window below the...

A flowerpot falls off a windowsill and falls past the window below. You may ignore air resistance. It takes the pot 0.420 s to pass from the top to the bottom of this window, which is 1.90 m high.

**Part A**

How far is the top of the window below the windowsill from which the flowerpot fell?

**ANSWER:**

\[ l = 0.310 \text{ m} \]

**Problem 2.85**

**Description:** Sam heaves a shot with weight 16-lb straight upward, giving it a constant upward acceleration from rest of \( a \) for a height \( h_1 \). He releases it at height \( h_2 \) above the ground. You may ignore air resistance. (a) What is the speed of the shot when he...

Sam heaves a shot with weight 16-lb straight upward, giving it a constant upward acceleration from rest of 35.8 m/s\(^2\) for a height 60.0 cm. He releases it at height 2.19 m above the ground. You may ignore air resistance.

**Part A**

What is the speed of the shot when he releases it?

**ANSWER:**

\[ v = \sqrt{2ah_1} = 6.55 \text{ m/s} \]
Part B
How high above the ground does it go?

ANSWER:
\[ h = \frac{ah_1}{9.8} + h_2 = 4.38 \text{ m} \]

Part C
How much time does he have to get out of its way before it returns to the height of the top of his head, a distance 1.84m above the ground?

ANSWER:
\[ t = \frac{\sqrt{2ah_1} + \sqrt{2ah_1 + 2 \cdot 9.8 (h_2 - h_3)}}{9.8} = 1.39 \text{ s} \]

Problem 2.94
Description: A ball is thrown straight up from the ground with speed \( v_0 \). At the same instant, a second ball is dropped from rest from a height \( H \), directly above the point where the first ball was thrown upward. There is no air resistance. (a) Find the time at...

A ball is thrown straight up from the ground with speed \( v_0 \). At the same instant, a second ball is dropped from rest from a height \( H \), directly above the point where the first ball was thrown upward. There is no air resistance.

Part A
Find the time at which the two balls collide.

Express your answer in terms of the variables \( H \), \( v_0 \), and appropriate constants.

ANSWER:
\[ t = \frac{H}{v_0} \]

Part B
Find the value of \( H \) in terms of \( v_0 \) and \( g \) so that at the instant when the balls collide, the first ball is at the highest point of its motion.

Express your answer in terms of the variables \( v_0 \) and \( g \).

ANSWER:
\[ H = \frac{(v_0)^2}{g} \]