

Reasoning Model - 1D Kinematics Items Version

8

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All Items

Ability to decode and understand English text. D is declarative knowledge P is procedural knowledge

- velocity and acceleration have to be in the same direction
- zero velocity implies zero acceleration
- acceleration is non-zero only when the graph is curved

1 Problem KD1-V3

- D: Define displacement as $x_f - x_i$
- P: Identify values for x_f and x_i from information given in text
- D: Identify "m" as meters
- D: Identify meters as a unit of measurement of position relative to an origin, distance, or displacement
- P: Perform subtraction
- D: Define displacement as a vector
- D: Know vectors require an indication of direction
- Incorrect path: Define displacement as $x_i - x_f$
- Incorrect path: Interpret "in the negative x direction" as meaning in the negative region of the number line (axis).

2 Problem KD10-V7EC

- P: identify north and south as indications of direction P: identify meters per second as an indication of change in position per unit time
- D: speed is a scalar quantity
- D: velocity is a vector quantity
- D: vectors require an indication of direction
- D: magnitude of velocity is speed
- Incorrect path: Belief that speed and velocity are interchangeable synonyms

3 KD5-V5-V4EC

P: Recognize that each square shows the location of an object at a given time

D: Velocity is displacement per unit time

D: Define displacement as $x_f - x_i$

P: Recognize that displacement per second is greater where squares are farther apart

P: Identify where sequential squares are farther apart and closer together on the figure

Incorrect path: Interpret "average velocity at points A, B, and C" as average velocity over entire trajectory until that point (flag for REVISION of figure to indicate region A, region B, and region C)

Incorrect path: Squares closer together implies more distance covered per second

Incorrect path: Squares closer together implies greater velocity (without explicit reasoning about displacement or distance covered)

4 KD1-6-V3

P: Recognize position vs time graph

P: Notice x is on the vertical axis, time on the horizontal

D: slope is rate of change of (thing on vertical axis) with respect to (thing on horizontal axis)

D: velocity is rate of change of position with respect to time

D: steepness of slope tells us about magnitude of slope

P: Recognize that slope is positive at all points on the graph

P: order by steepness of slope at points

P: correctly use $>$, $<$, and $=$ in inequalities

Incorrect path: order by position rather than by slope; no indication of knowledge of definition of velocity or slope as rate of change apparent

5 Problem KD1-8-V4EC

P: Recognize that left is negative and right is positive on axis shown

D: Sign of velocity indicates direction of motion

D: Constant velocity means object moves with constant speed in consistent direction

Incorrect path: Interpret arrow on axis as indicative of direction of motion (flag for REVISION of figure (arrow on each end))

Incorrect path: Interpret axis as indicating how much the object can travel and that the object has to do something when it reaches the end

6 Problem KD1-1-V6EC

- D: average speed is distance traveled per unit time
- D: average velocity is displacement per unit time
- D: speed is a scalar quantity
- D: displacement is a vector quantity
- P: Find distance traveled by adding magnitudes of legs of journey together
- P: Find displacement by subtracting final position from initial position
- Incorrect path to false positive: Calculate average velocity by adding -1 m/s and +1 m/s and dividing by 2 to get 0 m/s

7 Problem KD1-12

- P: Recognize position vs time graph
 - P: Notice x is on the vertical axis, time on the horizontal
 - D: slope is rate of change of (thing on vertical axis) with respect to (thing on horizontal axis)
 - D: velocity is rate of change of position with respect to time
 - P: recognize that graph is not curved
 - D: Know curve on position vs. time graph indicates changing velocity (acceleration)

8 Problem KD1-13-V5EC

- P: Recognize that this is a velocity vs time graph
 - D: slope is rate of change of (thing on vertical axis) with respect to (thing on horizontal axis)
 - D: acceleration is rate of change in velocity with respect to time
 - D: steepness of slope tells us about magnitude of slope, direction about sign
 - D: acceleration is a vector so negative accelerations are possible
 - P: Identify sign of slope at points on curve OR P: correctly use <, > and = in inequalities involving negative and positive quantities
 - Incorrect path: order by velocity rather than by slope; no indication of knowledge of definition of acceleration or slope as rate of change apparent
 - Incorrect path: acceleration and speed are interchangeable synonyms

9 Problem KD1-14-V3

- D: average acceleration is $\frac{v_f - v_i}{t_f - t_i}$ P: Identify v_f and v_i from information given in text P: Perform subtraction P: Recognize change in time will be positive so answer is negative divided by positive D: Negative divided by positive is negative
- OR
- P: Identify v_f that v_i are both positive and v_f is less than v_i from information given in text

P: Recognize that the object is slowing down as it moves in the positive direction

D: acceleration of an object moving in the positive direction and slowing down is negative

Incorrect path to false positive: D: slowing down always results from negative acceleration

10 Problem KD1-15-V2EC

D: area under a velocity vs time curve is displacement

P: Recognize area under both curves is positive and increasing for all times shown

P: Recognize area under curve for 2 is smaller than area under curve for object 1

D: if displacement is positive, it is the same as distance traveled

OR

P: Recognize that Object 1 is traveling at a greater velocity than Object 2 throughout the time shown P: Reason that an object that is moving faster covers more distance than a slower object

Incorrect path: D: (Graphs show the path an object takes so) length of the curve indicates distance traveled P: The curve shown for Object 2 is longer in length than object 1

Incorrect path: P: Recognize that the curves for Object 2 and Object 1 intersect at times 0 and B P: Conclude this indicates that the objects started at the same location and ended at the same location and must thus have traveled the same distance

11 KD17-V2EC

P: Recognize that this is a position vs time graph

D: slope is rate of change of (thing on vertical axis) with respect to (thing on horizontal axis)

D: velocity is rate of change in position with respect to time

D: acceleration is rate of change in velocity with respect to time

D: steepness of slope tells us about magnitude of slope, direction about sign

D: curvature of graph tells us about second derivative of (thing on vertical axis) with respect to (thing on horizontal axis)

D: acceleration is second derivative of position with respect to time

P: slope is constant and negative

P: lack of curve on position vs time graph means acceleration is zero

Incorrect path: D: acceleration always has the same sign as velocity

12 Problem KD1-18

D: sign of velocity gives direction of travel

D: if sign of acceleration is same as sign of velocity, speed increases; if signs of acceleration and velocity are opposite, speed decreases until velocity reaches zero

P: Identify that velocity and acceleration are both positive based on information in text

P: Reason that speed increases at all times after $t=0$

13 Problem KD1-48

P: recognize that these are position-time graphs

D: slope of position time graph is velocity

P: recognize that graphs with zero slope of first segment do not have a positive velocity for first 2.5 seconds as stated in problem

D: curvature of position-time graph indicates acceleration

14 Problem KD1-19-V3

D: sign of velocity gives direction of travel

D: if sign of acceleration is same as sign of velocity, speed increases; if signs of acceleration and velocity are opposite, speed decreases until velocity reaches zero and then object begins moving in the other direction

P: Identify that initial velocity is positive and acceleration is negative

P: Reason that speed decreases until object turns around and speeds up in opposite direction

Incorrect path: D: Objects accelerate due to forces P: No force is mentioned in the problem D: Once the object is at rest, it remains at rest

15 Problem KD1-20-V2EC

P: Recognize squares get closer together going from A to B

P: Reason that average velocity as object goes from one position marked on figure to the next will be distance between adjacent squares divided by one second since

-D: $\frac{(x_f - x_i)}{(t_f - t_i)}$

P: Reason that if average velocity goes down and movement is to the right over the entire interval, average acceleration must be negative since

-D: if sign of acceleration is same as sign of velocity, speed increases; if signs of acceleration and velocity are opposite, speed decreases until velocity reaches zero and then object begins moving in the other direction

Incorrect reasoning path (false positive): slowing down means negative acceleration, regardless of direction of velocity

16 Problem KD1-22-V2EC

P: Recognize that: Initially, object 1 covers less distance per unit time. By the end, object 1 covers more distance per unit time.

P: Recognize that the distance per unit time covered by object 2 is constant so they must have the same speed at some point during object 1's period of increasing speed.

P: object one is going slower at time 2 and faster at time 6.

OR D: Reference to calculus theorems

17 Problem KD1-23-V2

P: recognize that squares indicate position of each object at the given time D: velocity is displacement per unit time P: recognize that spacing of squares is consistent for each object

Incorrect path: greater space between squares for Object A means it has a greater velocity, and velocity and acceleration are interchangeable terms.

Incorrect path: greater space between squares for Object A means it has a greater velocity so it had to speed up more to reach that velocity.

Incorrect path: salience of 6s shown for Object A and 8s shown for Object B (flag for REVISION)

18 Problem KD1-32-V5EC

P: Recognize that these are velocity-time graphs

D: Area under the curve of a velocity-time graph equals displacement

D: Area can be positive or negative

OR

P: Recognize that these are velocity-time graphs

P: Recognize that Object 2 starts from zero velocity and ends up with the same velocity that Object 1 has the entire time

P: Reason that a car going 60 mph the whole time will go farther than a car that accelerates from rest to go 60 mph eventually (or other real-world analogue with Objects 1 and 2)

P: Reason that Object 3 must turn around since its velocity changes sign

P: Reason that Object 3 ends up less far from where it started because it doubled back

Incorrect path: Rank graphs by slope and/or change in velocity

19 Problem KD1-40-V2EC

P: recognize that the object turns around at point C

P: velocity changes from positive before reaching C to negative after reaching C

D: changing from positive to negative requires decreasing and going through zero

D: acceleration is change in velocity with respect to time

20 Problem KD1-44-V6EC

P: Recognize that these are velocity-time graphs

D: Area under velocity-time curve is displacement

P: Qualitatively compare areas of shapes and recognize that graph C has the largest area

OR

D: Velocity is displacement divided by change in time so velocity multiplied by time is displacement

P: Recognize that graph C shows a constant velocity while A, B, and D show velocities that reach a maximum equal to that of C but are lower over much of the time interval shown

P: Reason that a car going 60 mph the whole time will go farther than a car that accelerates from rest to go 60 mph eventually or one that starts at 60 mph and brakes (or other real-world analogue)

21 Problem KD1-41

D: velocity does not describe acceleration

22 Problem KD1-42-V6EC

D: acceleration does not describe velocity

D: if sign of acceleration is same as sign of velocity, speed increases; if signs of acceleration and velocity are opposite, speed decreases

P: velocity could be positive, negative, or zero with the information given

P: acceleration is positive so signs are the same if velocity is positive and opposite if velocity is negative

23 Problem KD1-38-V3AH

P: Recognize that this is a velocity-time graph

D: Object changes its direction of motion where velocity changes sign

P: Velocity changes sign where the graph crosses the x-axis

Incorrect path: velocity changes sign where the graph has a maximum or minimum (no explicitly acceleration-based reasoning given)

24 Problem KD1-18-V5EC

D: sign of velocity gives direction of travel

D: if sign of acceleration is same as sign of velocity, speed increases; if signs of acceleration and velocity are opposite, speed decreases

P: Identify that velocity is negative and acceleration is positive based on information in text

Incorrect path: positive acceleration is synonymous and interchangeable with speeding up

25 Problem KD1-52

D: Acceleration does not describe velocity

Incorrect path: acceleration always has the same sign as velocity

Incorrect path: negative acceleration is synonymous and interchangeable with slowing down