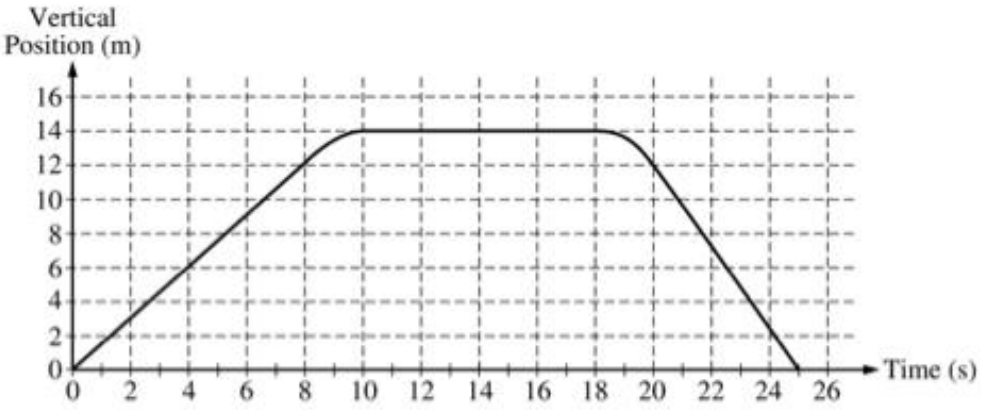
Kinematics Exam Review

Directions – Complete the following problems to help prepare you for the upcoming test.

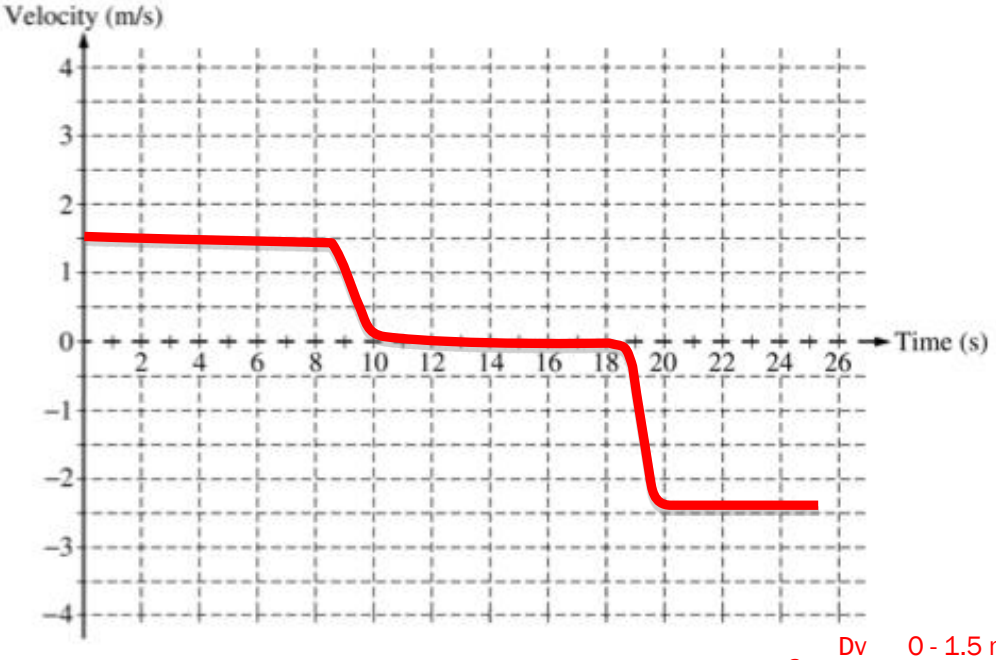
2005 AP® PHYSICS B FREE-RESPONSE QUESTIONS



1. (10 points)

The vertical position of an elevator as a function of time is shown above.

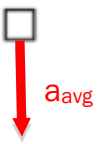
(a) On the grid below, graph the velocity of the elevator as a function of time.



(b) $a = \frac{\Delta v}{t} = \frac{0 - 1.5\ m/s}{2\ s} = -0.75\ m/s^2$

i. Calculate the average acceleration for the time period $t = 8$ s to $t = 10$ s.

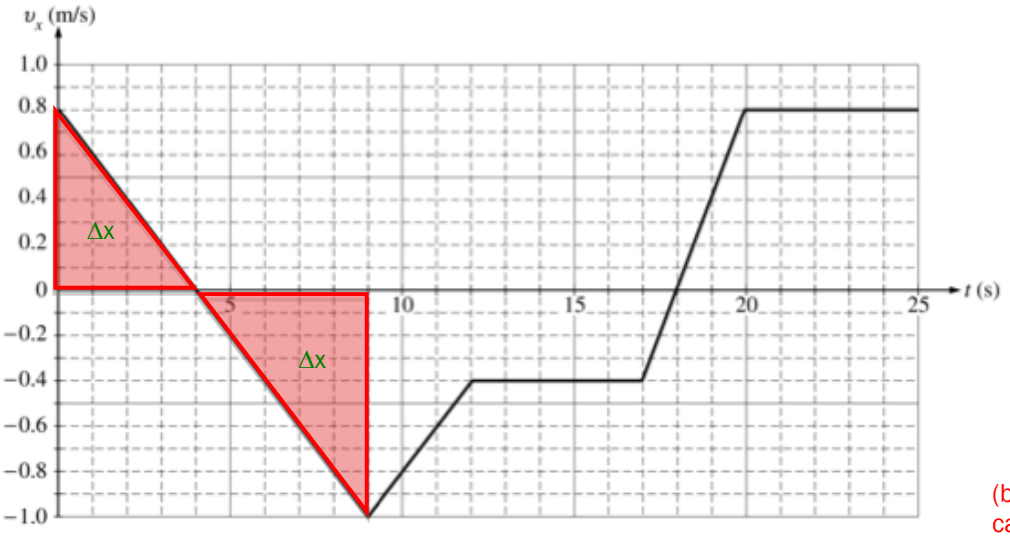
ii. On the box below that represents the elevator, draw a vector to represent the direction of this average acceleration.



2000 AP® PHYSICS B FREE-RESPONSE QUESTIONS

1. (15 points)

A 0.50 kg cart moves on a straight horizontal track. The graph of velocity v_x versus time t for the cart is given below.



(a) Indicate every time t for which the cart is at rest. (a) t = 4 s and t = 18 s

(b) Indicate every time interval for which the speed (magnitude of velocity) of the cart is increasing.

(b) The speed of the cart is increasing during the intervals t = 4s – 9s and 18s – 20s.

(c) Determine the horizontal position x of the cart at $t = 9.0$ s if the cart is located at $x = 2.0$ m at $t = 0$.

A = 1/2 bh + 1/2 bh

Dx = 1/2 (4 s)(0.8 m/s) + 1/2 (5 s)(-1.0 m/s)

Dx = -0.9 m

$Dx = v_i t + 1/2\ at^2$

$Dx = (0.8\ m/s)(9\ s) + 1/2(-0.2\ ms2)(9\ s)^2$

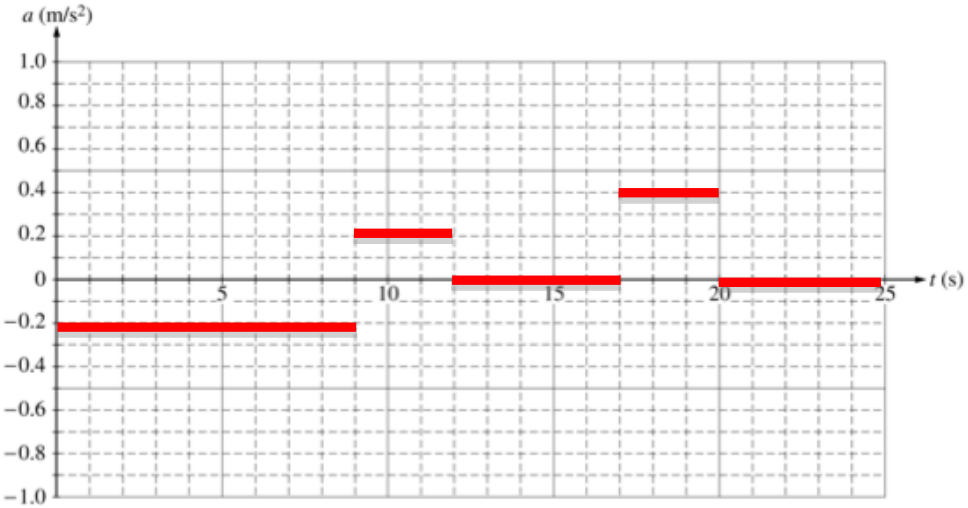
Dx = -0.9 m

$x = x_0 = Dx$

x = 2.0 m + (-0.9 m)

x = 1.1 m

(d) On the axes below, sketch the acceleration a *versus* time t graph for the motion of the cart from $t = 0$ to $t = 25$ s.



(e) From $t = 25$ s until the cart reaches the end of the track, the cart continues with constant horizontal velocity. The cart leaves the end of the track and hits the floor, which is 0.40 m below the track. Neglecting air resistance, determine each of the following.

i. The time from when the cart leaves the track until it first hits the floor (e$_i$) $t = \sqrt{\frac{2y}{g}} = \sqrt{\frac{2\ (0.40\ m)}{9.8\ m/s^2}} = 0.29$ s or 0.28 s

ii. The horizontal distance from the end of the track to the point at which the cart first hits the floor

$x = v_x t = (0.8\ m/s)(0.29\ s) = 0.23$ m or 0.22 m

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2. (15 points)

A world-class runner can complete a 100 m dash in about 10 s. Past studies have shown that runners in such a race accelerate uniformly for a time t_u and then run at constant speed for the remainder of the race. A world-class runner is visiting your physics class. You are to develop a procedure that will allow you to determine the uniform acceleration a_u and an approximate value of t_u for the runner in a 100 m dash. By necessity your experiment will be done on a straight track and include your whole class of eleven students.

(a) By checking the line next to each appropriate item in the list below, select the equipment, other than the runner and the track, that your class will need to do the experiment.

____ Stopwatches ____ Tape measures ____ Rulers ____ Masking tape

____ Metersticks ____ Starter's pistol ____ String ____ Chalk

(b) Outline the procedure that you would use to determine a_u and t_u, including a labeled diagram of the experimental setup. Use symbols to identify carefully what measurements you would make and include in your procedure how you would use each piece of the equipment you checked in part (a).

(c) Outline the process of data analysis, including how you will identify the portion of the race that has uniform acceleration, and how you would calculate the uniform acceleration.

15 points total — **Distribution of points**

Two general approaches were used by most of the students.

Approach A: Spread the students out every 10 meters or so. The students each start their stopwatches as the runner starts and measure the time for the runner to reach their positions.

Analysis variant 1: Make a position vs. time graph. Fit the parabolic and linear parts of the graph and establish the position and time at which the parabola makes the transition to the straight line.

Analysis variant 2: Use the position and time measurements to determine a series of average velocities ($v_{avg} = \Delta x/\Delta t$) for the intervals. Graph these velocities vs. time to obtain a horizontal line and a line with positive slope. Establish the position and time at which the sloped and horizontal lines intersect.

Analysis variant 3: Use the position and time measurements to determine a series of average accelerations $\left(\Delta x = v_0 t - at^2/2\right)$. Graph these accelerations vs. time to obtain two horizontal lines, one with a nonzero value and one at zero acceleration. Establish the position and time at which the acceleration drops to zero.

Approach B: Concentrate the students at intervals at the end of the run, in order to get a very precise value of the constant speed v_f, or at the beginning in order to get a precise value for a_u. The total distance D is given by $D = \left(a_u t_u^2/2\right) + v_f\left(T - t_u\right)$, where T is the total measured run time. In addition, $v_f = a_u t_u$. These equations can be solved for a_u and t_u (if v_f is measured directly) or v_f and t_u (if a_u is measured directly). Students may have also defined and used distances, speeds, and times for the accelerated and constant-speed portions of the run in deriving these relationships.

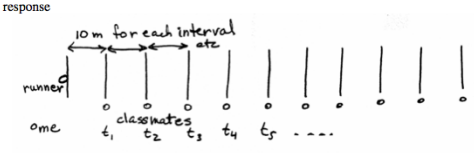
(a) 2 points

For checking off a distance-measuring device and describing its use in part (b)	1 point
For checking off a stopwatch and describing its use in part (b)	1 point

Distribution of points

(b) 6 points

Sample response



Use the tape measure and chalk to mark off the 100 meters in 10 meter lengths. Set a classmate with a stopwatch at marks as shown. Use the starter's pistol to signal the runner to run and the classmates to start their stopwatches. Each person turns off the stopwatch when the runner reaches his or her mark. You then have measurements of the time to reach each increment of 10 meters.

For taking distance measurements for 8 to 11 distinct fixed positions per run	1 point
For measuring time for the same 8 to 11 distinct fixed positions, consistent with the description of the experimental setup	1 point
For an experimental technique consistent with being able to determine the requested quantities	2 points
For a diagram of the experimental setup with clear labels and consistent with the technique described (awarded even if the technique is wrong)	1 point
For a technique that allows data for all positions to be taken in a single run	1 point

(c) 7 points

Approach A

For a clear and detailed explanation of the data analysis process *Note: This part of the solution was graded holistically and students could earn between 0 and 3 points depending on the clarity and completeness of their explanation.*	3 points
For equations or clear prose and use of the data to identify the two distinct regions of motion (constant acceleration and constant velocity)	1 point
For clearly and correctly identifying t_u	1 point
For clearly and correctly identifying a_u	1 point
For having the final answers correct and no incorrect statements or calculations among the correct ones	1 point

Distribution of points

(c) (continued)

Approach B

Students needed to clearly indicate which variable was used (acceleration or final velocity) by including the following.

For a description or diagram that clearly defines all the variables being used	1 point
For a description or diagram showing how the needed variable (acceleration or final velocity) will be determined	1 point
For a successful transformation of the above description into equation form	2 points
For correctly solving the equations obtained	1 point
For work that would determine a correct value of a_u	1 point
For work that would determine a correct value of t_u	1 point