

Useful Equations and Constants:

$$v_{av} = \frac{\Delta d}{\Delta t} \quad a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{\Delta t} \quad \Delta d = \frac{1}{2} (v_1 + v_2) \Delta t \quad \Delta d = v_2 \Delta t - \frac{1}{2} a (\Delta t)^2$$

$$\Delta d = v_1 \Delta t + \frac{1}{2} a (\Delta t)^2 \quad \Delta d = \frac{v_2^2 - v_1^2}{2a} \quad g = 9.80 \text{ m/s}^2 [\text{down}] \quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Part A: Multiple Choice Answers [10 marks]:

Write the letter representing the best answer for each question in the table below:

1	2	3	4	5	6	7	8	9	10
E	E	A	D	A	B	D	E	B	E

Part B: Short Answer and Problem Solving [38 marks]:

1. Is it possible for an object to have non-zero average speed but zero average velocity? Please give a supporting example to explain your answer. [2]

Yes!
 If an object returns to its starting point on any path, $\Delta d_R \neq 0$ but $\Delta d_T \neq 0$. \therefore the object will have a non-zero average speed but zero average velocity.

2. A curling stone travelling at 6.00 m/s [N] hits a patch of rough ice 3.00 m in width. After passing over the rough patch its velocity has been reduced to 3.50 m/s [N]. Find the acceleration of the stone as it travelled over the rough ice. [4]

$$\vec{v}_1 = 6.00 \text{ m/s [N]}$$

$$\Delta d = 3.00 \text{ m [N]}$$

$$\vec{v}_2 = 3.50 \text{ m/s [N]}$$

$$\vec{a} = ?$$

$$\text{Let } N = +$$

$$\Delta \vec{d} = \frac{\vec{v}_2^2 - \vec{v}_1^2}{2 \vec{a}}$$

$$\vec{a} = \frac{\vec{v}_2^2 - \vec{v}_1^2}{2 \Delta \vec{d}} = \frac{(3.50 \text{ m/s})^2 - (6.00 \text{ m/s})^2}{2(3.00 \text{ m})}$$

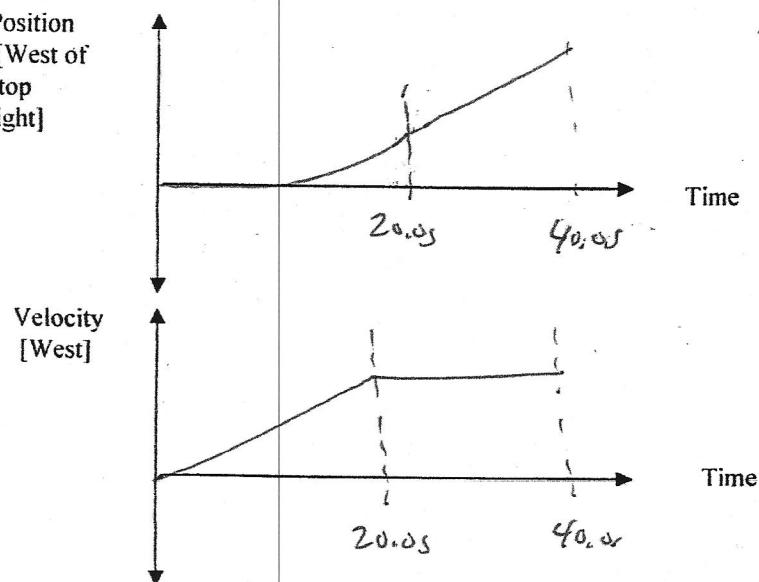
$$= -3.96 \text{ m/s}^2$$

\therefore the acceleration is 3.96 m/s^2 [S].

3. A car accelerates uniformly from rest at a rate of 1.25 m/s^2 [West] from a stop light for a time of 20.0 seconds. It reaches its top velocity and continues at this top velocity for another 20.0 seconds when it passes a slow moving truck up ahead.

- a) Sketch graphs of the car's position and velocity as a function of time.

[2]



- b) Find the total displacement the car underwent between leaving the stoplight and passing the ~~car~~ ^{truck}. [5]

$$\vec{v}_1 = 0.0 \text{ m/s}$$

$$\vec{a} = 1.25 \text{ m/s}^2 [\text{W}]$$

$$\Delta t_1 = 20.0 \text{ s}$$

$$\vec{v}_2 ?$$

$$\Delta t_2 = 20.0 \text{ s}$$

$$\vec{\Delta d}_{\text{Total}} ?$$

$$\text{Let } \vec{w} = +$$

$$\vec{\Delta d}_1 = \vec{v}_1 \Delta t_1 + \frac{1}{2} \vec{a} \Delta t_1^2$$

$$\vec{\Delta d}_1 = \frac{1}{2} (1.25 \text{ m/s}^2) (20.0)^2$$

$$\vec{\Delta d}_1 = 250.0 \text{ m} [\text{W}]$$

$$\vec{v}_2 = \vec{v}_1 + \vec{a} \Delta t_1$$

$$\vec{v}_2 = (1.25 \text{ m/s}^2)(20.0) = 25.0 \text{ m/s} [\text{W}]$$

$$\vec{\Delta d}_2 = \vec{v}_2 \Delta t_2 = (25.0 \text{ m/s})(20.0) = 500.0 \text{ m} [\text{W}]$$

$$\vec{\Delta d}_{\text{Total}} = \vec{\Delta d}_1 + \vec{\Delta d}_2 = 250.0 \text{ m} + 500.0 \text{ m} \\ = 750.0 \text{ m} [\text{W}]$$

the resultant displacement is

$$750.0 \text{ m} [\text{W}]$$

4. Ms. Ryan tosses a ball in the air with an initial velocity of 8.00 m/s [up]. The ball rises to a peak height and then falls back down into her hand. Ignoring air resistance determine:

a) The peak height the ball reaches. [3]

b) The time to reach the peak height. [3]

c) The time(s) at which the ball passes through a height of 2.00 m. [3]

a)

$$\vec{V}_i = 8.00 \text{ m/s [up]}$$

$$\vec{a} = \vec{g} = 9.80 \text{ m/s}^2 [\text{down}]$$

$$\vec{V}_2 = 0.0 \text{ m/s}$$

$$\Delta d = ?$$

Let up = +

$$\Delta d = \frac{\vec{V}_2^2 - \vec{V}_i^2}{2\vec{a}}$$

$$\Delta d = \frac{0 - (8.00 \text{ m/s})^2}{2(-9.80 \text{ m/s}^2)}$$

$$\Delta d = 3.27 \text{ m [up]}$$

b) $\Delta t = ?$

$$\Delta t = \frac{\vec{V}_2 - \vec{V}_i}{\vec{a}}$$

$$= \frac{0 - (8.00 \text{ m/s})}{(-9.80 \text{ m/s}^2)}$$

$$= 0.816 \text{ s}$$

c) $\Delta d = 2.00 \text{ m [up]}$

$$\Delta d = \vec{V}_i \Delta t + \frac{1}{2} \vec{a} \Delta t^2$$

$\Delta t = ?$

$$2.00 = 8.00 \Delta t - 4.90 \Delta t^2$$

$$-4.90 \Delta t^2 - 8.00 \Delta t + 2.00 = 0$$

$$a = 4.90 \quad b = -8.00 \quad c = 2.00$$

$$\Delta t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{8.00 \pm \sqrt{8.00^2 - 4(4.90)(2.00)}}{2(+4.90)}$$

$$= \frac{8.00 \pm 4.98}{9.80} = \boxed{0.308 \text{ s or } 1.325}$$

5. The hare and tortoise are running a race! The lazy hare decides to give the tortoise a head start and watches from the start line as the tortoise pulls away running at a constant velocity of 2.00 m/s [F]. After 45.0 seconds, the hare takes off after the tortoise, accelerating at a constant rate of 0.750 m/s² [F]. Determine the distance and time at which the hare catches the tortoise. If the race is only 120.0 m long, who wins?

Let H = hare T = Tortoise

$$\Delta d_T = (45.0 \text{ s})(2.00 \text{ m/s}) + V_T \cdot \Delta t$$

$$\vec{V}_T = 2.00 \text{ m/s [F]}$$

$$\Delta d_T = 90.0 \text{ m} + 2.00 \cdot \Delta t$$

$$\vec{a}_H = 0.750 \text{ m/s}^2 [P]$$

$$\Delta d_H = \frac{1}{2} a_H \Delta t^2$$

$$\Delta t_{\text{head start}} = 45.0 \text{ s}$$

$$\Delta d_H = \frac{1}{2} (0.750 \text{ m/s}^2) \Delta t^2 = 0.375 \Delta t^2$$

$\Delta d = ?$

$\Delta t = ?$

at meeting pt: $\Delta d_H = \Delta d_T$

$$0.375 \Delta t^2 = 2.00 \Delta t + 90.0$$

$$-0.375 \Delta t^2 - 2.00 \Delta t - 90.0 = 0$$

$$a = 0.375$$

$$b = -2.00$$

$$c = -90.0$$

$$\Delta t = \frac{2.00 \pm \sqrt{(2.00)^2 - 4(0.375)(-90.0)}}{2(0.375)} = -13.05 \text{ or } \boxed{18.395}$$

$$- \Delta d_T = 90.0 + 2(18.395) \\ = 176.8 \text{ m} \approx 127 \text{ m.}$$

they meet
in 18.4 s, 127 m
from the start!
The tortoise wins!!

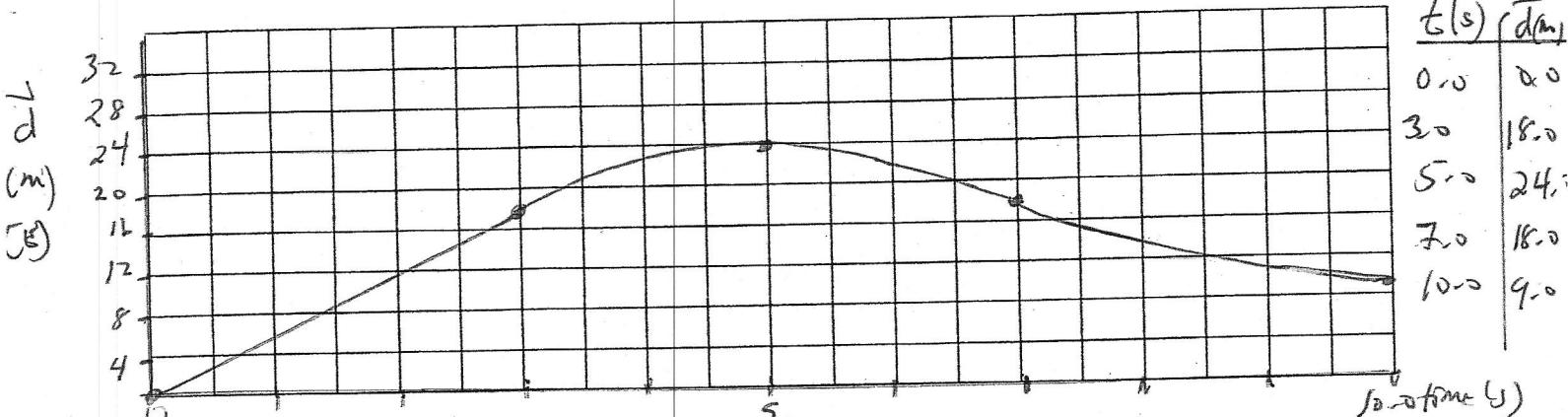
Part C: Graph Analysis [11 marks]

1. The motion of a train engine moving along a straight track in a railyard is shown on the velocity-time graph below.

i) Draw the corresponding acceleration-time graph for the train. [3]

ii) Assuming that the train starts at the station (origin), draw the corresponding position-time graph. [6]

Position-Time Graph:



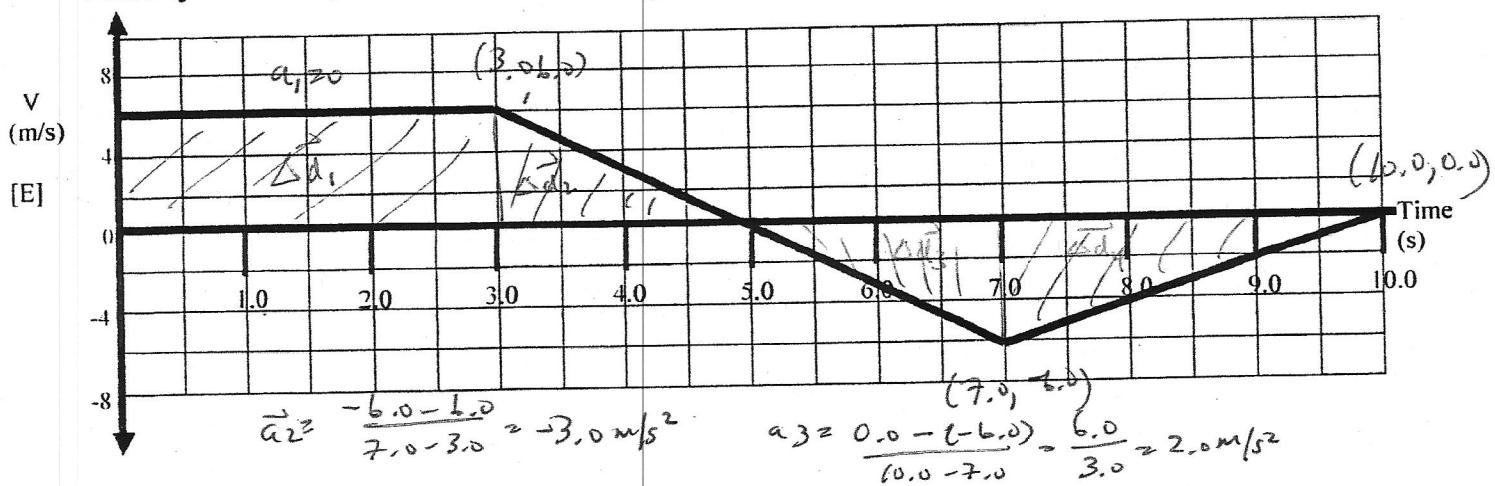
$$\vec{\Delta d}_1 = (3.0)(6.0) \\ = 18.0 \text{ m} [\text{E}]$$

$$\vec{\Delta d}_2 = \frac{1}{2}(2.0)(6.0) \\ = 6.0 \text{ m} [\text{E}]$$

$$\vec{\Delta d}_3 = -6.0 \text{ m} [\text{E}]$$

$$\vec{\Delta d}_4 = \frac{1}{2}(-6.0)(3.0) \\ = -9.0 \text{ m} [\text{E}]$$

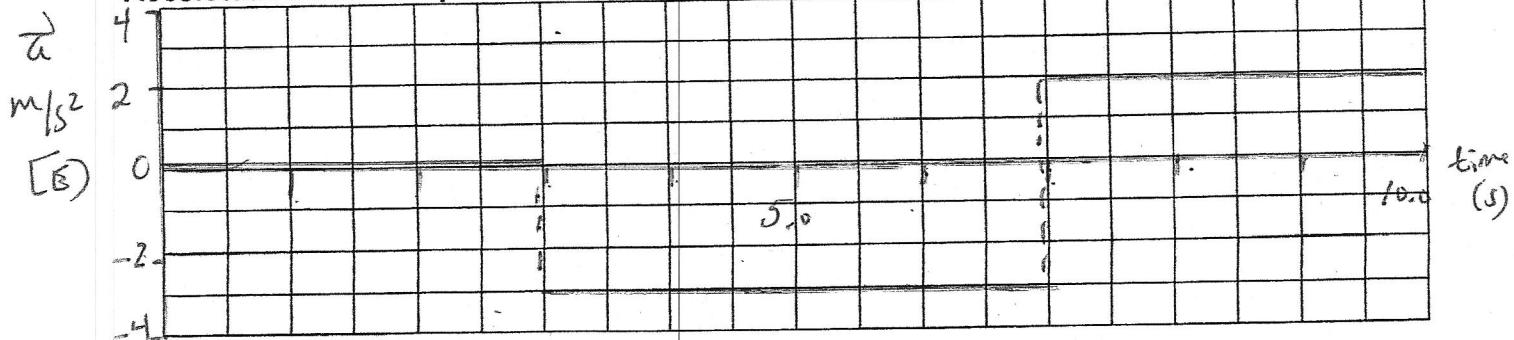
Velocity-Time Graph:



$$\vec{a}_2 = \frac{-6.0 - 6.0}{7.0 - 3.0} = -3.0 \text{ m/s}^2$$

$$a_3 = 0.0 - (-6.0) = \frac{6.0}{10.0 - 7.0} = 2.0 \text{ m/s}^2$$

Acceleration-Time Graph:



Describe the motion of the train:

It moves East at a constant velocity then slows down to a stop. It then reverses going west, first speeding up and then slowing down to a stop. [2]