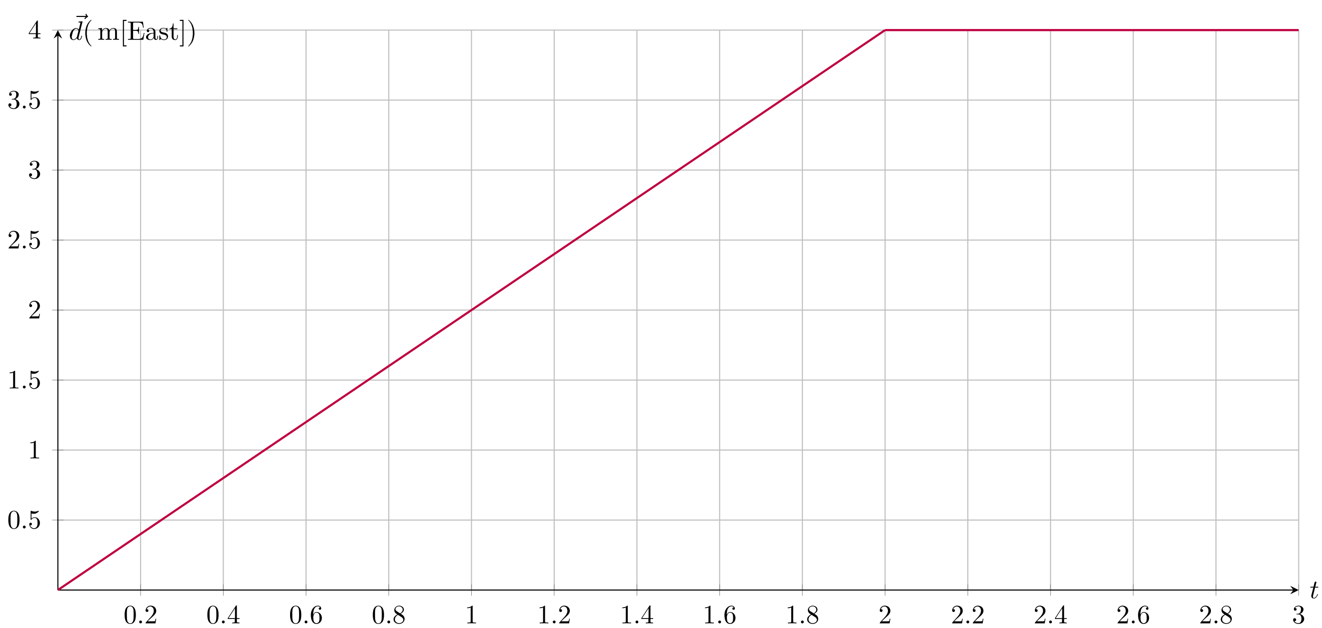
Question 1:

Answer the followiing True / False questions **(Assume [North],[East] is positive)**

1. I throw a rock $d = 100\,\mathrm{m}$ in the air and it returns to my hand in $\Delta t = 20\,\mathrm{s}$
   (a) The average speed of the ball was $v_{av} = 5\,\mathrm{m/s}$. (T / F) : F
   (b) The average velocity of the ball over $\Delta t = 20\,\mathrm{s}$ was $\vec{v}_{av} = +5\,\mathrm{m/s}$[North]. (T / F) : F
2. Suppose a rubber bullet travels at an average speed of $v_{av} = 600\,\mathrm{km/s}$ and an average velocity of $v_{av} = +600\,\mathrm{km/s}$.
   (a) The distance it can cover in $\Delta t = 4\,\mathrm{s}$ is $d = 2.4 \times 10^6\,\mathrm{m}$. (T / F) : F
   (b) Suppose the reference point is $(0, 0)$. If the gun is placed at $\vec{d_i} = +20\,\mathrm{m}$ and then fired, then after $\Delta t = 2\,\mathrm{s}$, $\vec{d_f} = +1.2 \times 10^3\,\mathrm{m}$. (T / F)
3. Suppose that the equation of motion for a rocket was $x = -4t - 6$. Then,
   (a) The rocket experienced uniform motion. (T / F)
   (b) The rocket experienced an average velocity of $\vec{v}_{av} = -10\,\mathrm{m/s}$. (T / F)
   (c) The rocket was initially [West] relative to the reference point. (T / F)
4. Suppose that a frisbee has an average speed of v_{av} and that it takes Δt seconds to reach the end of the room.
   (a) Doubling the average speed of the frisbee will triple the distance it can travel. (T / F)
   (b) If I want the frisbee to reach the end of the room in $\frac{\Delta t}{3}$ seconds then I must triple the average speed. (T / F)
5. Consider the Position V. Time graph for a body in motion below



(a) The body had an average velocity of $\vec{v}_{av} = +2\,\mathrm{m/s}$ over the time interval $[0, 2]$. (T / F)

(b) The body experienced uniform motion over the entire trip. (T / F)

(c) The body continued to move at a non-zero velocity in the positive direction after $t = 2\,\mathrm{s}$. (T / F)

6. On an island there are three points A, B, C that lie on a straight line. There is no information of $\vec{d}_{AB}$, I would like to obtain this vector. I can obtain this vector if there exists information of,

   (a) $\vec{d}_{AC}$, $\vec{d}_{BC}$. (T / F)

   (b) $\vec{d}_{CA}$, $\vec{d}_{CB}$. (T / F)

   (c) $\vec{d}_{AC}$, $\vec{d}_{CB}$. (T / F)

   (d) $\vec{d}_{BC}$, $\vec{d}_{CA}$. (T / F)

   (e) The average speed and the time elapsed from A, B. (T / F)

Question 2:

Convert the following quantities to $\mathrm{m/s}$

(a) $120\,\mathrm{mi/h}$

(b) $400\,\mathrm{km/h}$

(c) $368\,\mathrm{m/min}$

(d) $678\,\mathrm{in/min}$

Question 3:

Compute the **displacement** (or net displacement) given the position vectors. Assume that the reference point is $(0,0)$ for all vectors.

(a) $\vec{d_1} = 623\,\text{m}[\text{East}]$, $\vec{d_2} = 412\,\text{m}[\text{West}]$

Solution.

Lets make [East] positive,

$$\Delta\vec{d} = \vec{d_f} - \vec{d_i} = -412 - 623 = -1135$$

(b) $\vec{d_1} = +123\,\text{km}$, $\vec{d_2} = -81\,\text{km}$, $\vec{d_3} = -121\,\text{km}$, $\vec{d_4} = +610\,\text{km}$, $\vec{d_5} = +42\,\text{km}$, $\vec{d_6} = -742\,\text{m}$.

Solution.

$$\Delta\vec{d} = \vec{d_f} - \vec{d_i} = -742 - (+123) = -865$$

(c) $\vec{d_i} = 3\,\text{m}[\text{East}]$, $\vec{d_f} = 4\,\text{m}[\text{South}]$

Solution.

$$\Delta\vec{d} = \vec{d_f} - \vec{d_i} =$$

Question 4:

Determine the sum/difference of the following vectors **geometrically**. Use the $x-$dimensional coordinate system.

(a) $\vec{A} = +3$, $\vec{B} = -6$

$$\vec{A} + \vec{B}$$

(b) $\vec{A} = +4$, $\vec{B} = +8$, $\vec{C} = -20$, $\vec{D} = -12$

$$\vec{A} + \vec{B} - (\vec{C} - \vec{D})$$

(c) $\vec{A} = +2$, $\vec{B} = +18$, $\vec{C} = -12$, $\vec{D} = -8$, $\vec{E} = +7$

$$-\vec{A} + \vec{B} + \vec{C} - \vec{D} + \vec{E}$$

Question 5:

Suppose that vehicle has an average velocity of $\vec{v}_{av} = -3\,\mathrm{m/s}$. Suppose that he is initially at a position $\vec{d_i} = +5\,\mathrm{m}$ relative to the reference point. Choose the correct statement, and prove that it is true.

(a) The equation of motion for the vehicle is $x = 5t$

(b) The equation of motion for the vehicle is $x = 3t$

(c) The equation of motion for the vehicle is $x = -5t + 5$

(d) The equation of motion for the vehicle is $x = 5t + 5$

(e) The equation of motion for the vehicle is $x = -3t + 5$

(f) The equation of motion for the vehicle is $x = 5t + 5$

PROOF:

Solution.

Answer : e)

Proof. The proposition from S2 relates Position v. Time plots to average velocity, that being the fact that the slope of a Position on V. Time graph represents the average velocity of the body in motion, granted! that the graph is linear, and of course $x = -3t + 5$ is a linear equation. The second piece of information is the initial position vector, but that always corresponds to the y-intercept.In general if we have some linear equation, $x = mt + b$, the b-value corresponds to the initial positing vector. ∎

Question 6:

Suppose a train took the following route the other day to the following cities; Oshawa, Pickering, Markham, London (Starting at Oshawa). Given below are all of his position vectors along the trip (All relative to **Toronto**). Compute his average velocity as well as his average speed if the trip took 3 h.

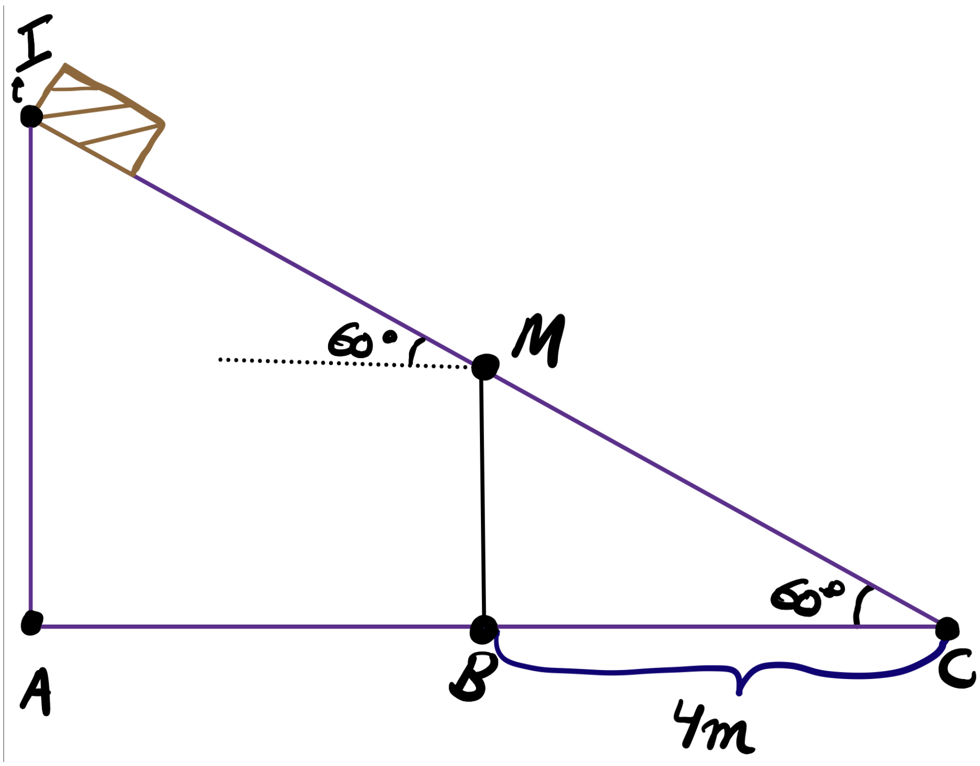
- $\vec{d}_{OSH} = 380\,\text{km}[\text{West}]$
- $\vec{d}_{PKR} = 434\,\text{km}[\text{West}]$
- $\vec{d}_{MRK} = 540\,\text{km}[\text{East}]$
- $\vec{d}_{LND} = 712\,\text{km}[\text{West}]$

Question 7:

Let us consider the current situation in a baton race. Racer A has an equation of motion $x_A = \frac{1}{2}t + 50$. Racer B has an equation of motion $x_B = 3t$. The race starts at $t = 0$, at what time will baton exchange happen between Racer A and Racer B? Plot both the motion of Racer A and Racer B at label the point where the exchange occurs.

Question 8:

Suppose that a wooden block slides down the ramp shown below at an average speed of $v_{av} = 10\,\mathrm{m/s}$. Suppose that it reaches point M at $t = 4\,\mathrm{s}$. Determine the height of the ramp (i.e Determine line segment IA).
(**Note:** We represent line segments in geometry from point A to point B as AB or BA, this may be helpful in shortening your solution)



Question 9:

Suppose that we have a straight line with three lights A, B, C. Suppose that we have the relative position vectors of these lights, $\vec{d}_{AB} = 56\,\text{m}[\text{East}]$, $\vec{d}_{CB} = 36\,\text{m}[\text{West}]$. Suppose that starting at light A, I traveled to the following sequence of lights $\{A, C, B, A, B, C\}$. If the entire journey took $\Delta t = 5\,\text{m}$, compute my average velocity over the journey as well as my average speed. (In m/s)

Question 10:

Suppose that I fire an arrow straight up into the air from a cliff at a position $\vec{d}_{CG} = 56\,\mathrm{m}[\mathrm{North}]$ relative to the ground. Suppose that a wooden box $14\,\mathrm{m}$ high is lying on the ground, and that the arrow lands directly on top of it. Compute the average velocity as well as the average speed of the arrow if the duration of the flight was $\Delta t = 45\,\mathrm{s}$.

Question 11:

Suppose that I kick a soccer ball across a 150 m wide field and that by the end of its flight it lands in a ditch 24 m deep. What was the vertical displacement of the ball? What was the horizontal displacement of the ball?

Question 12:

Suppose that a train coasting at an average speed of $250\,\mathrm{m/s}$ is headed for a mis-aligned track at a distance $2000\,\mathrm{m}$ ahead. A man on the train quickly grabs his scooter (which he had hidden away in his luggage) descends the train and attempts to switch the tracks alignment before the train reaches it. The scooter can ride at a maximum average speed of $300\,\mathrm{m/s}$. The train itself needs at least 3 seconds in order to come to a complete stop. Can the man successfully switch the track in time? Prove that your answer is correct

Solution.

Proof. For this problem, we know that the the time the train needs is at least 3 seconds. Lets say that the time that the train takes to reach the mis-aligned track is t seconds. Since we need at least 3 seconds to come to a complete stop, the man on the scooter must reach the track in (t - 3) seconds at the latest.

For ex : If the time it will take for the train to reach the track is t = 12 seconds, then the man has to reach the track at t = 9 seconds at the latest, anything after that is too late!

Now we have the setup, all we need to do is compute the time that the man on the scooter will reach the track if he travels at his maximum speed and compare that to the time it takes for the train to reach the track.

Time it takes for the train to reach the track : (2000) / 250 = 8 s

Time it takes for the man on the scooter to reach the track = (2000) / 300 = 6.67

We mentioned that the man on the scooter must reach the track at (t - 3) seconds at the latest, where t = time it takes for the train to reach the track. So (8 - 3) = 5 seconds is the latest time where he is allowed to reach the track, However the time where he reaches the track is 6.67 seconds, and this is beyond the latest time where he is allowed to reach the track. Therefore, the man cannot successfully switch the track in time.

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