**Question 11:**

Runner $A$ and Runner $B$ run back and forth across a 50 m track initially starting at position $(0,0)$ and facing [East] (Assume that [East] is the positive direction of motion). Runner $A$ has an average speed $v_{av} = 15\,\mathrm{m/s}$ and Runner $B$ has an average speed of $v_{av} = 20\,\mathrm{m/s}$. After an elapsed time of $\Delta t = 1\,\mathrm{min}$, what was the position vector of Runner $A$ relative to Runner $B$ (i.e $\vec{d}_{AB}$)

Finding position vector of runners by including elapsed time:

Runner A: 15m (60)
= +900m [East]

Runner B: 20m (60)
= 1200m [East]

The position vector of runner A relative to B could be found by recognizing A as the final vector and B as initial

So $\overset{A^*}{d_T} = d_f - d_i$
$= 900 - (1200)$
$= -300$ [West]

∴ This means the position vector of runner A relative to runner B is 300 m [West].

**Question 10:**


Suppose that I fire an arrow straight up into the air from a cliff at a position $\vec{d}_{CG} = 56\,\text{m}[\text{North}]$ relative to the ground. Suppose that a wooden box 14 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 $\Delta t = 45\,\text{s}$. (Hint : The reference point is your choice)

+ N

If the reference point is the cliff then we can conclude that the initial vector is 0m from the cliff.

The final vector can be calculated by the [illegible]

$\Delta \vec{d}_T = \vec{d}_F - \vec{d}_i$
$= -42 - (+0)$
$= -42$

∴ the total displacement was $-42$m or 42m [South].

$$\boxed{\vec{v}_{av} = \frac{-42\,m}{45\,s} = -0.93\ m/s}$$

Now lets find vav:

The distance the arrow travelled is the absolute value of the sums vers its path. for ex. $|d_1| + |d_2|$

So $|-42| = d$
$d = 42$m travelled

$$\therefore v_{av} = \frac{42\,m}{45\,s} = 0.93\ m/s$$

**Question 9:**

A bunny takes a tour around his neighborhood starting at his shelter. He travels 600 m[East] to House $A$, then from House $A$ he travels 754 m[West] to House $B$, then from House $B$ he travels 550 m[West] to House $C$, and then finally from House $C$ he travels 2 km[East] to House $D$. Compute his average velocity as well as his average speed if the elapsed time was $\Delta t = 2\,\text{min}$. (Assume that the shelter is the reference point)

$d_{SA} = +600$
$d_{AB} = -754$
$d_{BC} = -550$
$d_{CD} = +2$

Since we begin at the shelter and the shelter is the reference point, we can conclude that $d_i = +0m$. Since we know the reference point we also understand that the final vector must be house D relative to the shelter or $d_{DS}$.

$d_{BS} = d_{BA} + d_{AS}$
$= 754 - 600$
$= +154$

$d_{CS} = d_{CB} + d_{BS}$
$= 550 + 154$
$= 704$

$d_{DS} = d_{DC} + d_{CS}$
$= -2 + 704$
$= 702$

$\vec{v}_{av} = \dfrac{\vec{d}_f - \vec{d}_i}{\Delta t}$
$= \dfrac{702 - 0m}{2min}$
$= \dfrac{702km}{2mm}$ = ~~...~~

Step 2: calculating vav

$v_{av} = \dfrac{d}{\Delta T}$

* we require distance which is found by adding the sum of all displacements along the bunny's path.

$|d_1| + |d_2| + |d_3| + |d_4|$

~~...~~ $|600| + |-754| + |-550| + |2|$

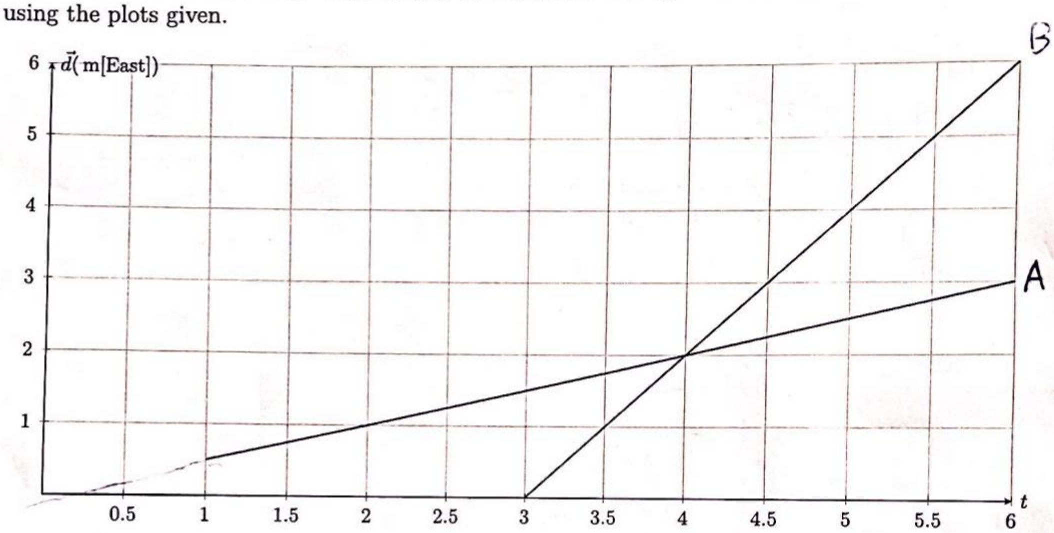
$= +1906km$

$\therefore$ $v_{av} = \left(\dfrac{1906km}{2mm}\right)\left(\dfrac{60min}{1hr}\right)$

=

**Question 8:**

Two tourists, Tourist A, Tourist B, decide to tour a city, below we depict their Position V. Time plots, <u>however</u>, we were only able to record information of Tourist A after $t = 1$, and information about Tourist B after $t = 3$. Your task is to determine the equations of motion for both Tourists using the plots given.




The form of the equation will be $x = mt+b$
By finding $b$ we will have a complete equation,

Tourist A: $x = \frac{1}{2}(1)+b$ (set $x=0$) $\quad x = \frac{1}{2}t - \frac{1}{2}$

$b = -\frac{1}{2}$

Tourist B: $x = 2(3)+b$ (set $x=0$)

$b = -6$

Tourist B: $x = 2t ~~4~~ - 6$

**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 4 h.

- $\vec{d}_{OSH} = 224\,\text{km[East]}$
- $\vec{d}_{PKR} = 154\,\text{km[East]}$
- $\vec{d}_{MRK} = 72\,\text{km[West]}$
- $\vec{d}_{LND} = 556\,\text{km[East]}$

Computing $\vec{V_{av}}$:

We know that all position vectors are relative to Toronto. However our initial position vector is +224 km [East] of Toronto since we begin in Oshawa. Our final position vector is London, which is +556 East of Toronto. The elapsed $\Delta T$ is 4hr, which was given in the question.

Therefore $\Delta \vec{d}_T = \vec{d}_f - \vec{d}_i$

$= +556 - (+224)$

$= 332\text{ km [East]}$

$\vec{V_{av}} = \dfrac{\Delta d}{\Delta T}$

$\vec{V_{av}} = \dfrac{+332}{4}$

$\vec{V_{av}} = 83\text{ km/h}$

Computing $V_{av}$:

$\vec{d_1} = Pkr - Osh$
$= -70\text{ km}$

$\vec{d_2} = Mrk - Pkr$
$= -72 - (+154)$
$= -226$

$\vec{d_3} = LND - Mrk$
$= +556 - (-72)$
$= 628$

The distance covered by an object is the sum of all displacements vectors its ways

$d = \sum_i |\Delta \vec{d_i}|$

$= |-70| + |628| + |226|$

$= 924$

$V_{av} = \dfrac{924\text{ km}}{4\text{ hr}}$

$V_{av} = 231\text{ km/h}$

**Question 5:**

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

(a) $\vec{A} = +2$, $\vec{B} = -8$

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

Geometrically we
* place the tail of b to the tip of A

$\vec{A} = +2$

$\vec{B} = -8$

$\vec{A} + \vec{B}$ = -8 +2 -6

$\vec{A} + \vec{B} = -6$

(b) $\vec{A} = +4$, $\vec{B} = -3$, $\vec{C} = +10$, $\vec{D} = -12$, $\vec{E} = -13$, $\vec{F} = +20$

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

$\vec{A} = +4$

$\vec{B} = -3$

$\vec{A} + \vec{B} = +1$

$= +1$

$\vec{C} = +10$

$\vec{D} = -12$

* we want $\vec{C} - \vec{D}$, for a vector $\vec{A}$, we define $-\vec{A}$ to be the vector such that $\vec{A} + (-\vec{A}) = 0$

$-\vec{D} = +12$

$\vec{C} - \vec{D}$ = +10 +12, +22

$= +22$

$\vec{E} = -13$

$\vec{F} = +20$

$-\vec{F} = -20$

$\vec{E} - \vec{F}$ = ~~-20~~ -13

$= -33$

$\vec{A} + \vec{B} =$ +1

$\vec{C} - \vec{D} = +22$

$-(\vec{C} - \vec{D}) = -22$

$\vec{E} - \vec{F} = -33$

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

-33 -22 +1

$= -54$

**Question 4:**

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

(a) $\vec{d_1} = 514\,\text{m[West]}$, $\vec{d_2} = 332\,\text{m[West]}$

As we know, the displacement of an object is its change in position $\vec{\Delta d} = \vec{d_f} - \vec{d_i}$

E+ →

$\vec{\Delta d} = (-332) - (-514)$

$= -332 + 514$

$= +182\,\text{m [East]}$

(b) $\vec{d_1} = 51\,\text{m[S]}$, $\vec{d_2} = 33\,\text{m[S]}$, $\vec{d_3} = 27\,\text{m[N]}$, $\vec{d_4} = 93\,\text{m[N]}$, $\vec{d_5} = 298\,\text{m[S]}$, $\vec{d_6} = 432\,\text{m[N]}$

↑ N+

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

$\Delta d_T = +432 - (-51)$

$= 432 + 51$

$= +483$

∴ The net displacement is 483 m [North]

(c) $\vec{d_1} = 4\,\text{m[East]}$, $\vec{d_2} = 4\,\text{m[West]}$, $\vec{d_3} = 4\,\text{m[North]}$, $\vec{d_4} = 4\,\text{m[East]}$

E+

$\Delta d_T = d_f - d_i$

$\Delta d_T = +4m - (+4m)$

$= +0\,m$

∴ The net displacement is 0m East since 0m West does not make sense

**Question 3:**

Covert the following units to km/h.

(a) 44200 m/s

$$\cancel{\left(\frac{44200\ m/s}{1}\right)} \quad \left(\frac{44\,200\ m}{1\ s}\right)\left(\frac{1\,Km}{1000\,m}\right)\left(\frac{3600\,s}{1\,hr}\right)$$

$$= \frac{159\ 120\ 000\ Km}{1000\ hr} = 159\ 120\ Km/h$$

(b) $5512 \times 10^4$ in/min (**1 inch = 2.54cm, 1 m = 100 cm**)

$$\left(\frac{5512000\,in}{1\,min}\right)\left(\frac{2.54\,cm}{1\,in}\right)\left(\frac{60\,min}{1\,hr}\right)\left(\frac{1\,m}{100\,cm}\right)\left(\frac{1\,Km}{1000\,m}\right)$$

$$= \frac{8\ 400\ 288\ 000}{100\ 000} = 8\ 4002.88\ Km/hr$$

(c) $336 \frac{\text{km}}{\text{week}}$

$$\frac{336\,Km}{168\ hr}$$

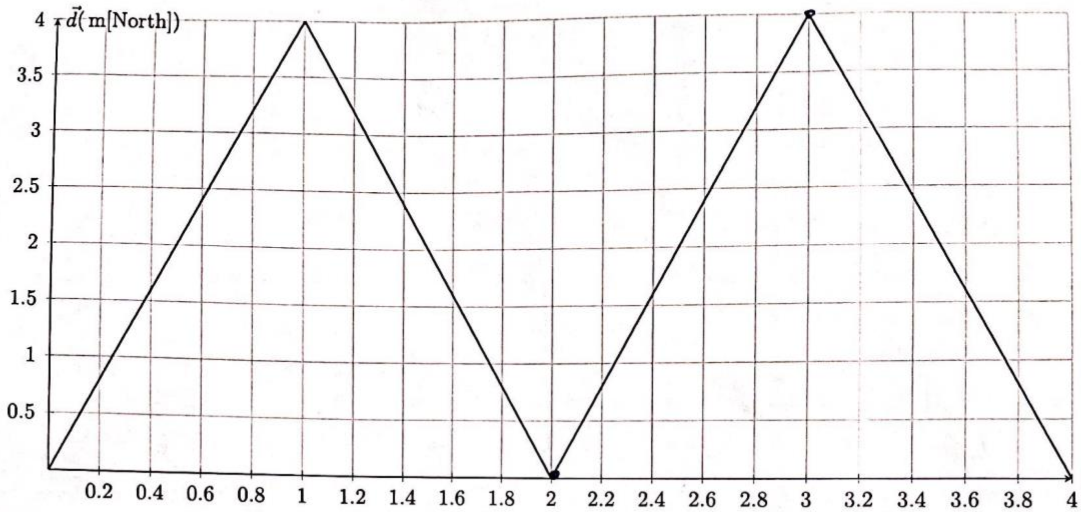
$$= 2\,Km/hr$$

3 4

20

## Question 2:

Answer the following multiple choice questions. Refer to the plot below for all Q1,Q2.




1. Which of the following scenarios best describe the motion depicted in the plot,
   (a) A ball rolling [North] across a flat road
   (b) A sprinter running on a circular track.
   (c) A man jumping on a trampoline.

$\frac{16}{4}$

2. Which of the following statements are correct about the plot?
   (a) The body experienced uniform motion within the time interval $[1, 2]$. $=4$
   (b) The body experienced uniform motion within the time interval $[0, 4]$
   (c) Within the time interval $[0, 2]$, the average velocity was $\vec{v}_{av} = +0\,\mathrm{m/s}$.
   (d) Within the time interval $[2, 3]$, the average velocity was $\vec{v}_{av} = +4\,\mathrm{m}/\,s$.
   (e) The average speed within the time interval $[0, 4]$ was $v_{av} = 4\,\mathrm{m/s}$.
3. I label three points on a straight line, $F$, $G$, $H$. Which of the following statements are true?
   (a) $\vec{d}_{FG} = \vec{d}_{GF} + \vec{d}_{GH}$
   (b) $\vec{d}_{HF} = (-\vec{d}_{FG}) + (-\vec{d}_{HG})$
   (c) $\vec{d}_{FH} = (-\vec{d}_{GF}) + (-\vec{d}_{HG})$
   (d) $-\vec{d}_{FG} = \vec{d}_{GH} + \vec{d}_{HF}$

**Question 1:**

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

1. The maximum height I can jump on a trampoline is $d = 5000\,\text{m}$. I jump 3 times on the trampoline and the time elapsed was $\Delta t = 20\,\text{s}$. (**Assume** that a single jump means I reached my maximum height **and** landed back on the trampoline)
   (a) My average velocity relative to the trampoline was $\vec{v}_{av} = +1700\,\text{m/s}$. (T / F)
   (b) My average speed was $v_{av} = 1.5\,\text{km/s}$. (T / F)
2. Suppose that relative to the center of a field, a batsmen stands at $\vec{d_i} = 50\,\text{m}$[East]. The batsmen bats a baseball at an average velocity of $\vec{v}_{av} = 350\,\text{m/s}$[West]. The time elapsed was $\Delta t = 15\,\text{s}$.
   (a) $\vec{d_f} = 5200\,\text{m}$[East] is the final position vector. (T / F)
   (b) The magnitude of the average velocity is equal to the average speed. (T / F)
3. Consider the Moon orbiting the Earth
   (a) The average velocity of the Moon is always non-zero after $t = 0$. (T / F)
   (b) The average speed of the Moon is always non-zero after $t = 0$. (T / F)

$V = \frac{\Delta d}{T} = \frac{\Delta d}{0}$

4. Consider the equation of motion of Car A : $x = -\frac{3}{2}t + 12$ and Car B : $x = \frac{7}{2}t - 7$
   (a) Car $A$ has a greater average speed than Car $B$. (T / F)
   (b) Car $B$ is initially [East] relative to the reference point. (T / F)
   (c) Car $A$ is initially [West] relative to the reference point. (T / F)
   (d) Both drivers experienced uniform motion. (T / F)
   (e) Car $A$ and Car $B$ will meet at $t = 4\,\text{s}$. (T / F)
5. I kick a soccer ball at an average speed $v_{av}$ and it takes $\Delta t$ seconds to reach a distance of $d$ meters.
   (a) Kicking the soccer ball at $2v_{av}$ will allow it to travel $\frac{d}{2}$ meters in $\Delta t$ seconds. (T / F)
   (b) Kicking the soccer ball at $\frac{v_{av}}{2}$ implies that it would take $2\Delta t$ seconds to travel $d$ meters. (T / F)

$V_{av} = \frac{d}{\Delta T}$

$2v_{av} = \frac{2d}{\Delta t}$