AP Physics C: UNIT CONVERSION

1. Convert each of the following measurements into the specified units.

a. 42.3 cm = ____**423**__ mm

d. 0.023 mm = ____**0.23**___ cm

1 cm = 10 mm

b. 6.2 pm = _**0.0000000000062**_ m

1 picometer = 10^{-12} meters

e. 214 μm = __**0.000214**_ m

1 micrometer = 10^{-6} meters

c. 21 km = ___**21,000**_ m

1 kilometer = 10^{3} meters

f. 570 nm _**0.00000000057**_ km

1 nanometer = 10^{-9} meters

2. Rank the following mass measurements from smallest to largest:

11.6 mg = **0.0116 gm**, 1021 μg = **0.001021 gm**, 0.0000006 kg = **0.0006 gm**, 0.31 mg = **0.00031 gm**

0.0006 gm < 0.00031 gm < 0.001021 gm < 0.0116 gm

3. Convert each of the quantities to specified equivalents

a. 353 ft to ___**106.9**__ m

$$353\ ft \times \frac{1\ m}{3.3\ ft} = 106.9\ m$$

c. 5 cm^3 to _**0.000005**_ m^3

$$5\ cm^3 \times \frac{1\ m}{100\ cm} \times \frac{1\ m}{100\ cm} \times \frac{1\ m}{100\ cm} = 0.000005\ m^3$$

b. 2.0 in to ____**50.5**___ mm

$$2.0\ in \times \frac{1\ ft}{12\ in} \times \frac{1\ m}{3.3\ ft} \times \frac{1000\ mm}{1\ m} = 50.5\ mm$$

d. 1000 m^2/day to ___**3,974,850**___ft^2/year

$$1000\ \frac{1\ m^2}{day} \times \frac{365\ days}{1\ yr} \times \frac{3.3\ ft}{1\ m} \times \frac{3.3\ ft}{1\ m} = 3{,}974{,}850\ ft^2/year$$

1 Warhol = 15 minutes of fame based on Andy Warhol's famous line: "Everybody will have 15 minutes of fame."	**1 Wheaton = half a million Twitter™ followers** Based on the number of followers celebrity Will Wheaton had
1 Kardashian = 72 days Based on how long a Kardashian marriage lasts	**1 Parsec = unit of astronomical distance** = 3.08567758 × 10^{16} meters

4. Use the table of values above to solve the following problem. Mr. Spock ran 5 x 10^{-12} *parsecs* in 0.04 *Kardashians*. For his great feat he was awarded two *Warhols* during which his Twitter™ followership increased to 4 *Wheatons*.

a. ____**0.62 m/s**___Find Spock's speed (in m/s).

$$\frac{5 \times 10^{-12}\ parsecs}{0.04\ Kardashians} \times \frac{1\ Kardashian}{72\ days} \times \frac{1\ day}{24\ hrs.} \times \frac{1\ hr.}{3600\ s} \times \frac{3.08567758 \times 10^{16}\ m}{1\ parsec} = 0.62\ m/s$$

b. ____**69.6 hrs.**_______Find the total time Spock ran + the time he was famous (in hours).

$$0.04\ Kardashians \times \frac{72\ days}{1\ Kardashian} \times \frac{24\ hrs.}{1\ day} + 2\ Warhols \times \frac{15\ min}{1\ Warhol} \times \frac{1\ hr}{60\ min} = 69.6\ hrs.$$

c. __**1111 followers/s**_____ What was the rate of growth of Mr. Spock's Twitter™ followership (in followers per second)?

$$\frac{4\ Wheatons}{2\ Warhols} \times \frac{500{,}000\ followers}{1\ Wheaton} \times \frac{1\ Warhol}{15\ min.} \times \frac{1\ min.}{60\ s} = 1111.11\ followers/s$$

AP Physics C: DIMENSIONAL ANALYSIS

The following are dimensions of various physical parameters that will be discussed later on in the year. Here [L], [T], and [M] denote, respectively, fundamental dimensions of length, time, and mass.

UNIT	SYMBOL	DIMENSION	UNIT	SYMBOL	DIMENSION
Distance	x	[L]	Mass	m	[M]
Acceleration	a	[L]/[T]^2	Energy	E	[M][L]^2/[T]^2
Time	t	[T]	Speed	v	[L]/[T]
Force	F	[M][L]/[T]^2			

Which of the following equations are dimensionally correct? Show the work that verifies this.

1. $v_2 = v_1 \cdot t + a$

$\frac{L}{T} = \frac{L}{T}(T) + \frac{L}{T^2} \rightarrow \frac{L}{T} = L + \frac{L}{T^2} \rightarrow \frac{L}{T} = \frac{L(T^2)}{T^2} + \frac{L}{T^2} \rightarrow \frac{L}{T} \neq \frac{L(T^2)+L}{T^2}$

2. $v_f = \frac{v_1+v_2}{2}$

$\frac{L}{T} = \frac{L}{T} + \frac{L}{T} \rightarrow \frac{L}{T} = \frac{2L}{T} \rightarrow \frac{L}{T} = \frac{L}{T}$ ✓

3. $x = v \cdot t^2 + ½ \cdot a \cdot t$

$L = \left(\frac{L}{T}\right) \cdot T^2 + \frac{L}{T^2} \cdot T \rightarrow L = L \cdot T + L \cdot T \rightarrow L \neq L \cdot T$

4. $v_2^2 = v_1^2 + 2 \cdot a \cdot x^2$

$\left(\frac{L}{T}\right)^2 = \left(\frac{L}{T}\right)^2 + \frac{L}{T^2} \cdot L^2 \rightarrow \frac{L^2}{T^2} = \frac{L^2}{T^2} + \frac{L^3}{T^2} \rightarrow \frac{L^2}{T^2} \neq \frac{L^2+L^3}{T^2}$

5. $x = ½\, v \cdot t^2 + a \cdot t$

Same as 3 above: $L = \left(\frac{L}{T}\right) \cdot T^2 + \frac{L}{T^2} \cdot T \rightarrow L = L \cdot T + L \cdot T \rightarrow L \neq L \cdot T$

6. $F = m \cdot a$

$\frac{ML}{T^2} = (M)\left(\frac{L}{T^2}\right) \rightarrow \frac{ML}{T^2} = \frac{ML}{T^2}$ ✓

7. $x = ½ \cdot a \cdot t^2$

$L = \left(\frac{L}{T^2}\right) \cdot T^2 \rightarrow L = L$ ✓

8. $E = ½ \cdot m \cdot v$

$\frac{ML^2}{T^2} = M \cdot \frac{L}{T} \rightarrow \frac{ML^2}{T^2} \neq \frac{ML}{T}$

9. $E = m \cdot a \cdot x$

$\frac{ML^2}{T^2} = (M) \cdot \left(\frac{L}{T^2}\right) \cdot L \rightarrow \frac{ML^2}{T^2} = \frac{ML^2}{T^2}$ ✓

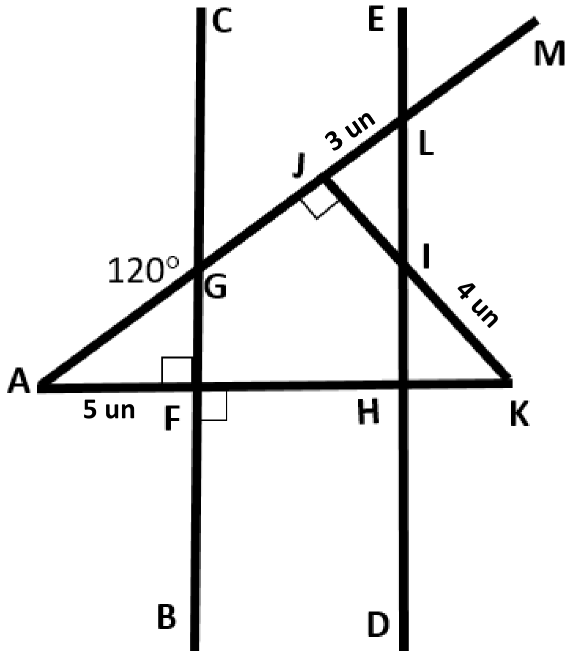
10. $v = \sqrt{\frac{F \cdot x}{m}}$ $\quad \frac{L}{T} = \sqrt{\frac{\frac{ML}{T^2} \cdot L}{M}} \rightarrow \frac{L}{T} = \sqrt{\frac{ML}{T^2} \cdot L \div M} \rightarrow \frac{L}{T} = \sqrt{\frac{M^2L^2}{T^2}} \rightarrow \frac{L}{T} \neq \frac{ML}{T}$

11. A spring is hanging down from the ceiling and an object of mass *m* is attached to the free end. The object oscillates up and down, and the time *T* required for one complete up-and-down oscillation is given by the equation $T = 2\pi\sqrt{\frac{m}{k}}$, where *k* is known as the spring constant. What must be the dimension of *k* for this equation to be dimensionally correct?

$T = 2\pi\sqrt{\frac{m}{k}}$ $\quad T = \sqrt{\frac{M}{k}} \rightarrow T^2 = \left(\sqrt{\frac{M}{k}}\right)^2 \rightarrow T^2 = \frac{M}{k} \rightarrow k = \frac{M}{T^2} = \frac{kg}{s^2}$

AP Physics: TRIANGLE GEOMETRY AND TRIGONOMETRY

DIRECTIONS: Find the missing values requested.



BC || DE
∠BFA = ?
∠AGF= ?
∠FAG= ?
∠CGJ = ?
∠IKH = ?

∠HIJ = ?
∠IJL = ?
∠ILJ = ?
∠HKI= ?
∠FGJ = ?
∠ELM = ?

$\overline{\mathbf{JI}}$ **= ?**
$\overline{\mathbf{IL}}$ **= ?**
$\overline{\mathbf{HK}}$ **= ?**
$\overline{\mathbf{IH}}$ **= ?**
$\overline{\mathbf{AG}}$ **= ?**
$\overline{\mathbf{GF}}$ **= ?**

Ans. ∠BFA = 90°, because supplementary angles = 180° (90° + ∠BFA = 180°)
∠AGF = 60° because supplementary angles = 180° (since ∠AGC = 120°).
∠FAG = 30° because the sum of the angles of a triangle ΔAFG = 180°
∠CGJ = 60° because supplementary angles = 180°
∠IKH = ∠HKI = 60° because of the following…

- **∠ELJ = 120° since corresponding angles are congruent (∠ELJ ≅ ∠AGC),**
- **therefore ∠ELM = 60° because supplementary angles = 180°,**
- **∠JLI = 60°, because vertical angles are congruent (∠ELM ≅ ∠JLI),**
- **∠IJL = 90° because supplementary angles = 180°,**
- **∠LIJ = 30°, because the sum of the angles of a triangle ΔLIJ = 180°,**
- **∠HIK = 30° because vertical angles are congruent (∠LIJ ≅ ∠HIK).**
- **∠IHK = 90° because BC || DE and AK ⊥ BC so it must also be ⊥ DE.**

∠FGJ = 120° because vertical angles are congruent
∠HIJ = 150° because supplementary angles = 180°

To find $\overline{\mathrm{JI}}$: tan θ = $\frac{\text{opp.}}{\text{adj.}}$ → tan ∠JLI = $\frac{\overline{\mathrm{JI}}}{\overline{\mathrm{JL}}}$ → tan 60° = $\frac{\overline{\mathrm{JI}}}{3\text{ un}}$ → $\overline{\mathrm{JI}} = 3 \cdot \tan 60°$ → $\overline{\mathrm{JI}} = 5.20$ un

To find $\overline{\mathrm{IL}}$: $a^2 + b^2 = c^2$ → $c = \sqrt{a^2+b^2}$ → $\overline{\mathrm{IL}} = \sqrt{3^2 + 5.20^2} = \sqrt{36} = 6$ un

To find $\overline{\mathrm{HK}}$: cos θ = $\frac{\text{adj.}}{\text{hyp.}}$ → cos ∠HKI = $\frac{\overline{\mathrm{HK}}}{\overline{\mathrm{KI}}}$ → cos 60° = $\frac{\overline{\mathrm{HK}}}{4\text{ un}}$ → $\overline{\mathrm{HK}} = 4 \cdot \cos 60°$ → $\overline{\mathrm{HK}} = 2$ un

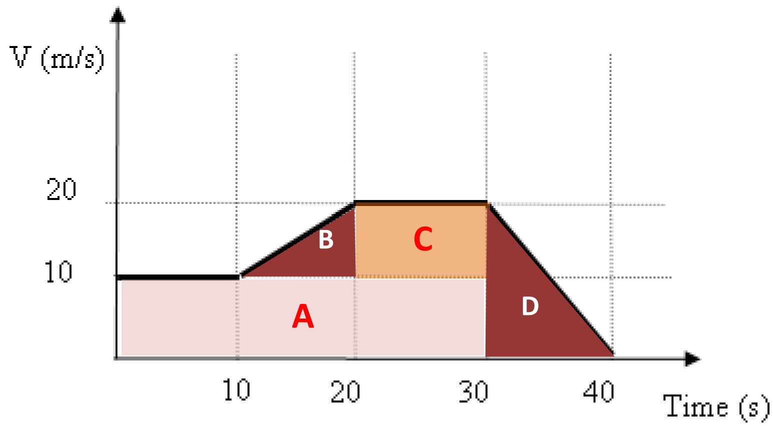
To find $\overline{\mathrm{IH}}$: $a^2 + b^2 = c^2$ → $a = \sqrt{c^2 - b^2}$ → $\overline{\mathrm{IH}} = \sqrt{4^2 - 2^2} = \sqrt{12} = 3.46$ un

To find $\overline{\mathrm{AG}}$: cos θ = $\frac{\text{adj.}}{\text{hyp.}}$ → cos ∠FAG = $\frac{\overline{AF}}{\overline{\mathrm{AG}}}$ → cos 30° = $\frac{5\text{ un}}{\overline{\mathrm{AG}}}$ → $\overline{\mathrm{AG}} = \frac{5}{\cos 30°}$ → $\overline{\mathrm{AG}} = \frac{5}{\cos 30°} = 5.78$ un

To find $\overline{\mathrm{FG}}$: $a^2 + b^2 = c^2$ → $a = \sqrt{c^2 - b^2}$ → $\overline{\mathrm{FG}} = \sqrt{5.78^2 - 5^2} = \sqrt{8.333} = 2.87$ un

AP Physics: AREA UNDER A CURVE

DIRECTIONS: Find the area under the graph shown.



Ans. Area A + Area B + Area C + Area D = 10 × 30 + ½×10×10 + 10 × 10 + ½×10×20

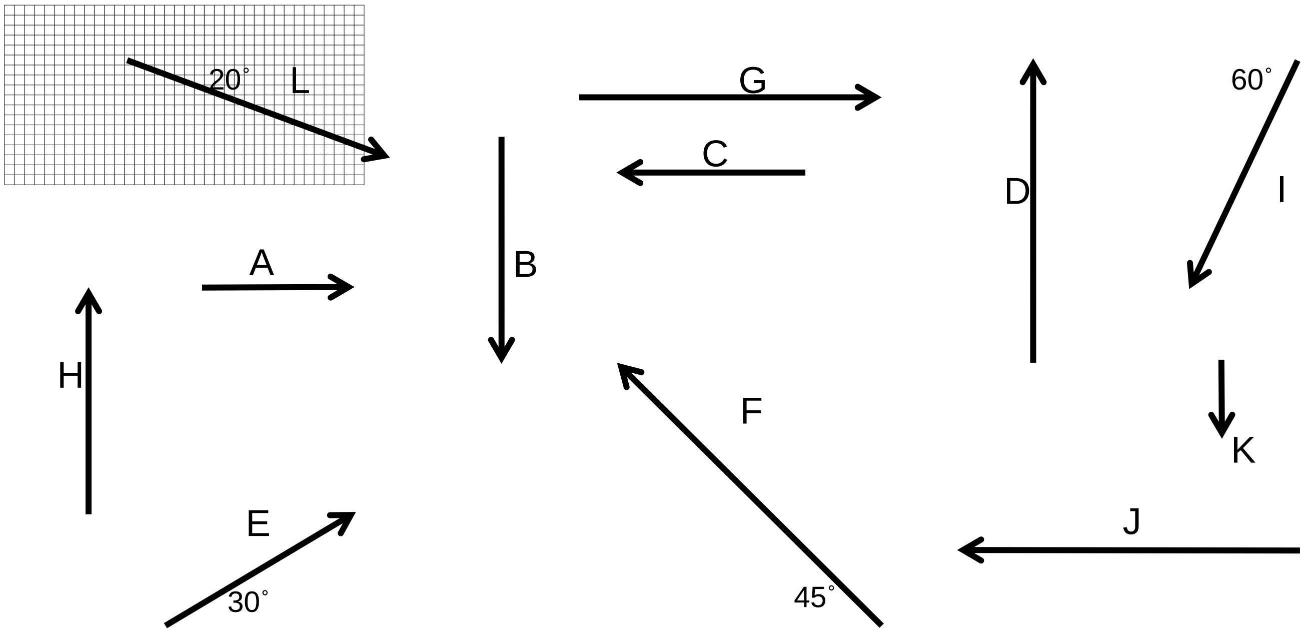
= 300 + 50 + 100 + 100

Answer: ______**550**______________________________

Answer with units included: ______**550 (m/s × s) = 550 m**____________

CONCLUSION: The units of your answer reveal that if you find the area between a **velocity vs time graph of an object** and the **x-axis,** you have actually found the **distance** travelled by the object.

AP Physics: VECTOR MATH



DIRECTIONS: Using the vector diagrams drawn, determine the magnitude and direction of each vector quantity.

A = **4 units, 0°**

B = **6 units, 270°**

C = **5 units, 180°**

D = **8 units, 90°**

E = $\cos\theta = \frac{\text{adj.}}{\text{hyp.}} \rightarrow \cos 30° = \frac{\text{5 un.}}{\text{hyp.}}$

$\rightarrow \text{hyp} = \frac{\text{5 un.}}{\cos 30°} =$ **5.77 un**

F = $\sin\theta = \frac{\text{opp.}}{\text{hyp.}} \rightarrow \sin 45° = \frac{\text{7 un.}}{\text{hyp.}} \rightarrow$

$\text{hyp} = \frac{\text{7 un.}}{\sin 45°} =$ **9.89 un**

G = **8 units, 0°**

H = **6 units, 90°**

I = $\sin\theta = \frac{\text{opp.}}{\text{hyp.}} \rightarrow \sin 60° = \frac{\text{6 un.}}{\text{hyp.}} \rightarrow$

$\text{hyp} = \frac{\text{6 un.}}{\sin 60°} =$ **3.46 un**

J = **9 units, 180°**

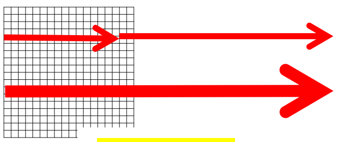
K = **2 units, 270°**

L = $\cos\theta = \frac{\text{adj.}}{\text{hyp.}} \rightarrow \cos 20° = \frac{\text{7 un.}}{\text{hyp.}}$

$\rightarrow \text{hyp} = \frac{\text{7 un.}}{\cos 20°} =$ **7.45 un**

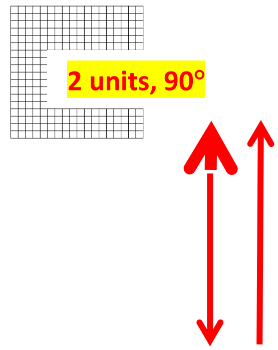
DIRECTIONS: In the blank grids below, perform each vector operation GRAPHICALLY using the head-to-tail method. State the magnitude and direction of the resultant vector.

A + G



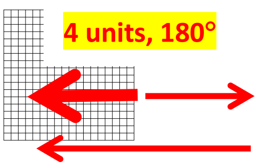
12 units, 0°

B + D



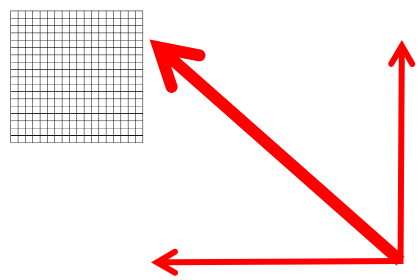
2 units, 90°

A – G



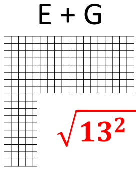
4 units, 180°

D + J



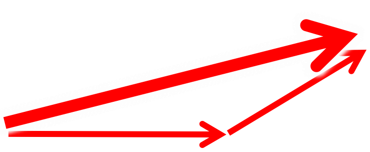
$\sqrt{8^2 + 8^2} = \sqrt{128}$ un, 45°

E + G

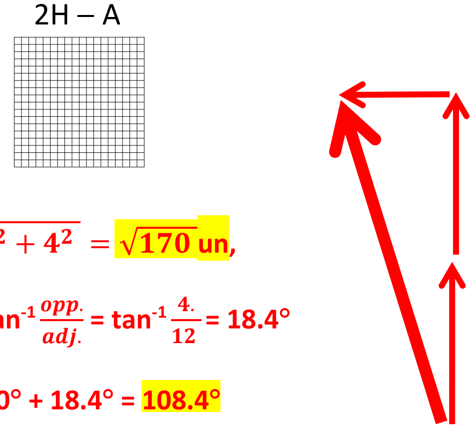


$\sqrt{13^2 + 3^2} = \sqrt{178}$ un,

$\theta = \tan^{-1}\frac{opp.}{adj.} = \tan^{-1}\frac{3.}{13} = 13.0°$



2H – A



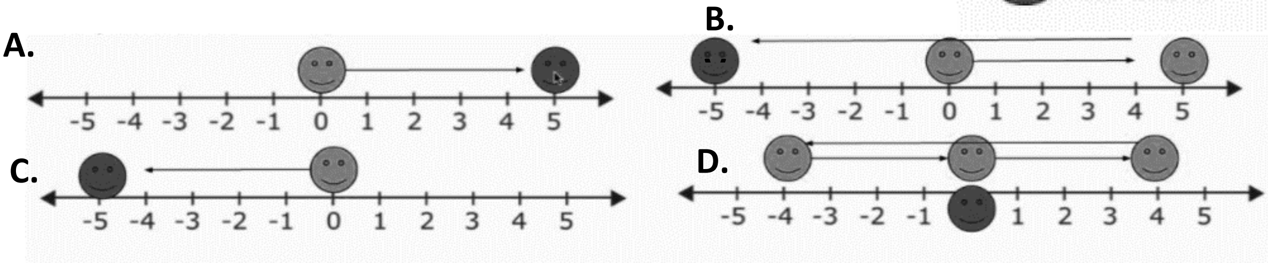
$\sqrt{12^2 + 4^2} = \sqrt{170}$ un,

$\theta = \tan^{-1}\frac{opp.}{adj.} = \tan^{-1}\frac{4.}{12} = 18.4°$

$\theta = 90° + 18.4° = 108.4°$

AP Physics: DISPLACEMENT, DISTANCE, SPEED, VELOCITY

DIRECTIONS: Use the specific definitions of the terms displacement, distance, speed, and velocity to find the following.



DIRECTIONS: The emoji starts at the origin in each of the above cases. Find:

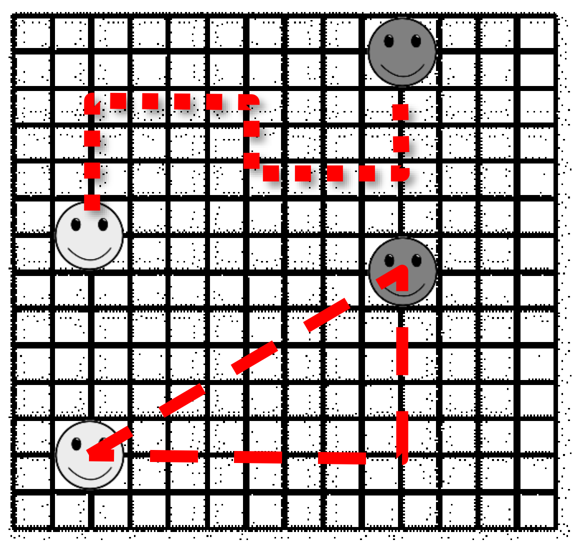
a. The **distance** the emoji traveled for A – D. **For A = 5 units, For B = 15 units, For C = 5 units, and For D = 20 units**

b. The **displacement** of the emoji from the origin for A – D. **For A = 5 units, For B = –5 units, For C = –5 units, and For D = 0 units**

c. The **speed** of the emoji for A – D if each trip took 5 seconds. **s = $\frac{d}{t}$, For A: s = $\frac{5}{5}$ = 1 un/s, For B: s = $\frac{15}{5}$ = 3 un/s, For C: s = $\frac{5}{5}$ = 1 un/s, and For D: s = $\frac{20}{5}$ = 4 un/s**

d. The **velocity** of the emoji for A – D if each trip took 5 seconds. **v = $\frac{x}{t}$, For A: v = $\frac{5}{5}$ = 1 un/s, For B: v = $\frac{-5}{5}$ = –1 un/s, For C: v = $\frac{-5}{5}$ = –1 un/s, and For D: v = $\frac{0}{5}$ = 0 un/s**

DIRECTIONS: The emoji goes 2-dimensional and moves on the graph paper as shown at right.



a. The **distance** the emoji traveled from A – B.

b. Ans. 17 units

c. The **displacement** of the emoji from A – B

$\sqrt{8^2 + 5^2} = \sqrt{89}\ \text{un}$

d. The **speed** of the emoji if it took 10 seconds to cover the distance.

s = $\frac{17\ un}{10\ s} = 1.7\ un/s$

e. The **velocity** of the emoji if the trip took 10 seconds.

v = $\frac{x}{t} = \frac{\sqrt{89}}{10} = 0.94\ un/s$