Name: _____ Period: _____ Date: _____

Unit 2 Review Packet (15 pts)

Defining Motion

We defined **motion** to be a change in an object's position. To measure a change of position, you need a **reference frame** – a object or set of objects that you make your measurements from.

All motion is measured within some reference frame. When you're riding the bus, you might choose a reference frame like...

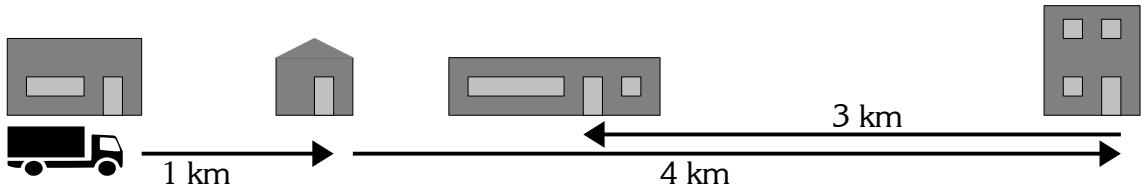
- ...the bus itself! Compared to the bus you aren't moving because your position doesn't change.
- ...the street or buildings outside! Compared to the street you are moving because your position changes as the bus drives along.

After school, suppose you walk from EA down to the Wendy's on Main St. After you eat, you come back up to school to wait for your ride. The total **distance** you walk is nearly 2 km, but you end up right where you started, so your **displacement** is 0 km. A displacement tells *the distance and direction* between your starting and ending points, ignoring everything that happens in between. For example, "2 km east" is a displacement.

1) When choosing a reference frame, why is a stationary object better than a mobile object?

2) Suppose you walk 7 blocks west, then 3 blocks east. What distance did you walk? What is your displacement?

3) The diagram below shows the route taken by a delivery truck.



What distance has it driven? What is its displacement?

4) If you complete one lap of the 400 m track in phys. ed. class, what is your displacement?

Speed and velocity

When an object is in motion, the most basic thing you can ask about it is "how fast?" **Speed** tells you how far an object will move during a given amount of time. For example, a speed of "60 miles per hour" means that the object would go 60 miles in 1 hour.

Once you know "how fast?", the other question you might want to know is "which direction?" Speed only tells you how fast, but **velocity** tells you how fast *and* which direction. For example, "15 cm/s" is a speed but "15 cm/s to the north" is a velocity. You can also turn a speed into a velocity by putting a + or − sign on it, since your reference frame defines which way is the positive (+) direction. So, if your reference frame says "right is +, left is −"... then "+15 cm/s" is a velocity telling you the speed *and* direction of motion.

Mathematically, speed is defined as the ratio of how far an object moves and how much time it needs to do it. You can rearrange that formula through algebra to calculate the speed, the distance, or the time:

$$speed = \frac{distance}{time} \qquad time = \frac{distance}{speed} \qquad distance = speed \cdot time$$

Most objects don't move with a single, consistent speed. The speed usually changes from moment to moment. For example, while a car drives down the road it speeds up and slows down pretty often even if it doesn't have to stop. The driver might slow down to let a car coming the other way get by, speed up to get through a traffic light, or gently press the brakes while going around a corner. If you measure its speed in a single instant – like the speedometer on the car does – we call that an **instantaneous speed**.

Usually, though, you don't need to know the details of motion in every single instant. The average motion of the object is more important. When you calculate a speed by dividing the total distance and the total time (like the formulas above) we call that an **average speed**.

5) For each of the following, indicate whether it's a speed or a velocity.

A. 25 cm/s _____
B. 15 m/s right _____
C. −10 km/h _____
D. 384.32 cm/s _____
E. 2 m/s toward the window _____
F. 88 mm/year _____

6) In the picture above, which two bugs have the same speed but different velocities?

7) In the picture above, which two bugs have the same velocity?

8) A car drives a distance of 250 km in a time of 1.5 h. What is its speed?

9) A car drives a distance of 400 km at a speed of 80 km/h. How much time will this take?

10) A car drives at a speed of 100 km/h for a time of 3.5 h. What distance does it travel?

11) Suppose your *average speed* while you walk down the hall at school is 1.0 m/s. Your *instantaneous speed* might be higher or lower at any given moment. Give an example of something that might slow you down, and an example of something that might speed you up.

12) On a plane trip to California, you first take a flight from Columbus to Detroit. This is a trip of 154 miles and takes about 1.3 hours. Then you wait in Detroit for 0.8 hours. Finally, you get on another plane and fly to sunny San Diego. This flight is 1951 miles and takes 4.9 hours.
    A. What is the TOTAL DISTANCE for this trip?

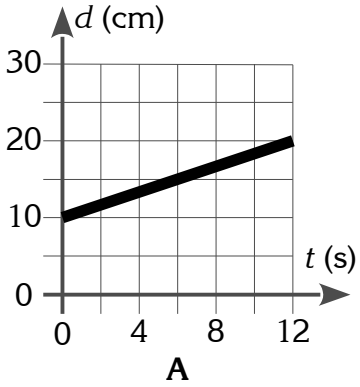
    B. What is the TOTAL TIME for this trip?

    C. What is the average velocity for the trip?

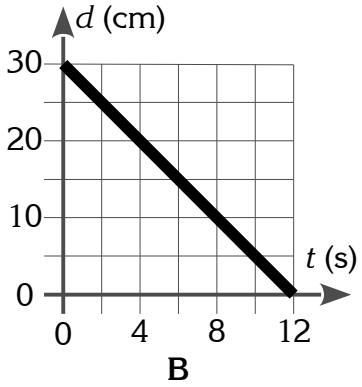
Distance graphs

One of the simplest ways to show data about an object's motion is with a distance graph. Distance graphs show where things are at different times.

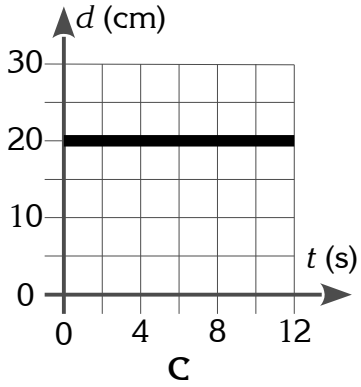
A useful feature of a distance graph is that *the slope of the graph equals the object's velocity*. So you can tell how fast the object was moving and which direction it was going. (Remember: + and − are directions based on your reference frame.) This makes it easy to compare the speeds of objects on a single graph: the steepest one is fastest.



A



B



C

13) On graph A, where was the object at time 6 s?

14) On graph B, where did the object start?

15) On graph B, when was the object at a position of 5 cm?

16) On graph C, where was the object at time 0 s? What about time 2 s? 8 s?

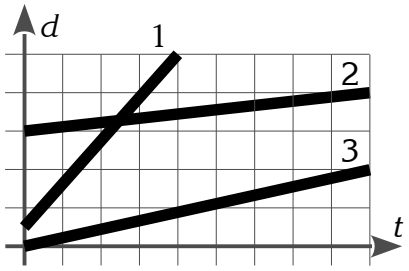
17) Find the slope of graph A.

18) What is the velocity of the object shown in graph B?

19) Describe in words what the object in graph C is doing.

20) Rank the objects in this graph based on their speeds.

Slowest _____ < _____ < _____ Fastest



Acceleration

Whenever an object's velocity changes, we call that an **acceleration**. Since velocity is an object's speed and direction, that means an acceleration can be speeding up, slowing down, or changing direction. To calculate acceleration, you need to figure out how much the velocity changed and then divide by the time:

$$acceleration = \frac{change\ of\ velocity}{time}$$

$$accel = \frac{\Delta vel}{time} \qquad time = \frac{\Delta vel}{accel} \qquad \Delta vel = accel \cdot time$$

To save space in the bottom row of formulas, some abbreviations are used and a triangle symbol, the **Greek letter delta**, is put in place of the words "change of...".

When solving acceleration problems, *don't forget to find the change of velocity*. For example, if a velocity changes from $+15$ m/s to $+12$ m/s, the change is -3 m/s.

Like velocities, accelerations can be either + or −. The sign tells you which direction the acceleration is in, just like it does for velocity. Assuming that the object has a + velocity, a + acceleration means it's getting faster while a − acceleration would mean it's getting slower.

21) A car speeds up from 0 m/s to 6 m/s over a time of 3 s. What is its acceleration?

22) A car slows down from 12 m/s to 0 m/s over a time of 4 s. What is its acceleration?

23) A car speeds up from 15 m/s to 30 m/s over a time of 5 s. What is its acceleration?

24) How long will it take for a parked truck to reach 40 m/s if it accelerates at a rate of 2 m/s^2? (Since the truck starts out parked, its starting velocity must be 0 m/s.)

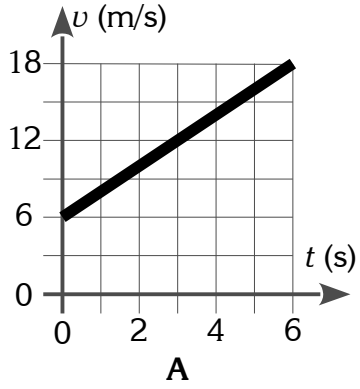
25) A cyclist pedals hard for 10 s. If the bike's acceleration is 0.6 m/s^2, how much will its velocity change during that time?

26) A soccer ball is kicked and begins rolling at $+10$ m/s. Friction with the grass slows the ball down with an acceleration of -1.5 m/s^2. After 4 seconds, what will the ball's velocity be?

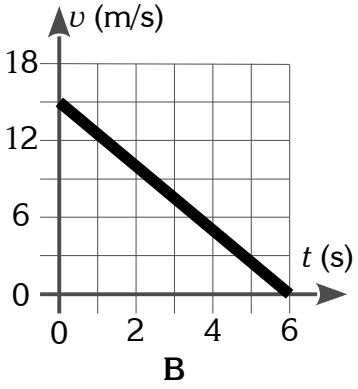
Velocity graphs

A graph of velocity (or speed) can tell you how fast an object was moving at any given moment. Since you can see changes in the velocity on these graphs, it shouldn't surprise you that *the slope of the graph equals the object's acceleration*.

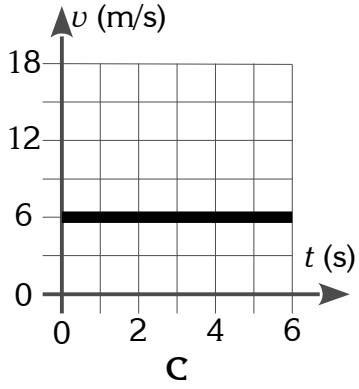
Just as with accelerations that you find using formulas, a + slope means an object is getting faster and a − slope shows it getting slower.



A



B



C

27) On graph A, what was the object's speed at time 5 s?

28) On graph B, where velocity did the object start with?

29) On graph B, when did the object have a velocity of 3 m/s?

30) On graph C, what speed did the object have at time 0 s? What about time 1 s? 4 s?

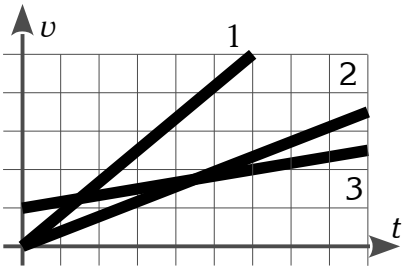
31) Find the slope of graph A.

32) What's the acceleration of the object shown in graph B?

33) Describe in words what the object in graph C is doing.

34) Rank the objects in this graph based on their accelerations.

Most _____ > _____ > _____ Least



Units are your friend

Throughout this unit, a lot of students have had trouble recognizing or remembering the proper types of units to use for different kinds of information. Here are the base units we've used so far:

Measurement	SI Unit	Other example units
Length or distance	m	km, cm
Time	s	min, h
Mass	kg	g
Volume	L	mL, cm^3

And here are the derived units that combine base units:

Measurement	Description	Example units
Density	mass over volume	g/mL, g/cm^3, kg/L
Speed or velocity	distance over time	m/s, cm/s, km/h
Acceleration	distance over TWO times	m/s^2, cm/s^2, $km/h/s$

It's critical that your answers to science problems have the right units on them. But learning units can also help you solve problems in the first place: If you can tell that “5 m/s” is a velocity just by looking at it, you'll never plug it into a formula as a time or an acceleration. You'll make fewer mistakes and be able to solve problems more quickly.

State what kind of measurement each of these is:

35) 15 m _____
36) 231 g/mL _____
37) 647 g _____
38) 34 m/s _____
39) 1.58 cm/s^2 _____
40) 31.4 min _____
41) 80 km/s _____
42) 5 s _____
43) 68 km/h^2 _____
44) 1.74 mL _____