NAME: KEY

Linear Speed

Concepts:

A. *Linear Speed* simply refers to how fast an object is moving along a line or a curve, and is measured in m/s. (It was what we have been doing all year long.) When talking about motion on a circle, it is sometimes called *tangential speed*. Why is that?

Because it is moving tangent to the circle it is traveling in

B. *Rotational Speed* refers to how quickly something rotates. What do you think units of rotational speed could be? There are many, and you have probably heard of some of them.

rpm Hertz

rotations/sec

C. If you go one time around a circle that has a redius of "r" what distance do you travel?

The circumference! $d = 2\pi r$

D. What is the most basic way to think of speed?

distance/time

E. If we call the time to go around a circle once the period and use the letter "T" to represent that, what would be a good equation to calculate the speed of an object going around in a circle of radius "r" with a period of "T?"

$$V = \frac{2\pi r}{T}$$

Problems:

1. You are walking in circles with a radius of 150 meters in a big field. It takes you 5 minutes to go around once.
   c. How far do you travel in going around once?

$$d = 2\pi r = 2\pi(150) = 300\pi = 942 \text{ m}$$

   d. What is your linear speed?

$T = (5 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) = 300 \text{ s}$

$$v = \frac{2\pi r}{T} = \frac{942}{300} = 3.14 \text{ m/s}$$

2. A sock stuck to the inside of the clothes dryer spins around the drum once every 2.0 s at a distance of 0.50 m from the center of the drum.
   a. What is the sock's linear speed?

$T = 2 \text{ s}$
$r = 0.5 \text{ m}$

$$V = \frac{2\pi r}{T} = \frac{2\pi(.5)}{2} = 1.57 \text{ m/s}$$

Linear Speed

b. If the drum were twice as wide but continued to turn with the same frequency, would the linear speed be faster than, slower than or the same as your answer to part a?

Since $v = \frac{2\pi r}{T}$ if r was bigger, then v would be bigger

(in fact, if r doubles, so does v. If r triples, so does v. etc.)

3. Charlotte twirls a round piece of pizza dough overhead with a frequency of 60 revolutions per minute.
   a. How many seconds will it take the pizza dough to rotate once?

Since 1 minute = 60 seconds, 60 revolutions in 60 seconds means only **1 second** to go around once.

   b. Find the linear speed of a piece of pepperoni stuck on the dough 10 cm from the pizza's center.

$T = 1$

$r = 10\text{ cm} = 0.1\text{ m}$

$v = \frac{2\pi r}{T} = \frac{2\pi(.1)}{1} = $ **0.63 m/s**

   c. In what direction will the pepperoni move if it flies off while the pizza is spinning? Explain.

It will fly off tangent to the circle

   d. What is the frequency in Hertz?

$\left(\frac{60\text{ revolutions}}{\text{minute}}\right)\left(\frac{1\text{ minute}}{60\text{ seconds}}\right) = 1\text{ rps} =$ **1 Hz**

4. A car has a constant speed of 12 m/s while it drives around in a circle. The radius of the circle is 50 meters.
   a. How many seconds will it take the car to go around once?

$v = 12\text{ m/s}$

$r = 50\text{ m}$

$v = \frac{2\pi r}{T}$ $\quad 12 = \frac{2\pi(50)}{T}$ $\quad T = \frac{2\pi(50)}{12}$

$T = 26.2$ s

   b. It has a constant speed – so why is it also accelerating?

because the direction it is moving is always changing.

   c. What is the frequency in Hz of the car?

$T = 26.2$ s $\quad f = \frac{1}{T}$ $\quad f = \frac{1}{26.2}$ $\quad$ **$f = 0.038$ rps**

Linear Speed

5. A record player works by spinning a record at a constant rate of 33.3 rpm. A needle then floats in a groove that spirals around the record, moving from the edge of the album to the middle of the album. (The needle picks up the vibrations from the groove, and turns it into an electrical signal.)
   a. How many seconds will it take for one complete rotation?

$f = 33.3$ rpm $\quad T = \frac{1}{f} = \frac{1}{33.3} = 0.030$ min $\quad (0.030 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) = 1.8$ s

   b. What is the linear speed of a point on the edge of the record with a radius of 15 cm?

$r = 15 \text{ cm} = 0.15 \text{ m}$, $T = 1.8$ s $\quad v = \frac{2\pi r}{T} = \frac{2\pi(.15)}{1.8} = 0.52$ m/s

   c. What is the linear speed of a point in the middle of the record with a radius of 5 cm?

$r = 0.05$ m, $T = 1.8$ s $\quad v = \frac{2\pi r}{T} = \frac{2\pi(.05)}{1.8} = 0.174$ m/s

6. A CD player works by spinning the CD and having a small laser track a groove etched into the CD. (The laser looks at little pits that are in the groove, and sends a digital signal back to the processor.) The laser always moves with a constant linear speed that depends on the player, but let's say the linear speed is 12 m/s.
   a. When the laser is on the inside of the CD with a radius of 5 cm, what is the frequency of the spinning CD?

$v = 12$ m/s, $r = 5 \text{ cm} = 0.05$ m

① $v = \frac{2\pi r}{T} \quad 12 = \frac{2\pi(.05)}{T} \quad T = \frac{2\pi(.05)}{12} = 0.026$ s

② $f = \frac{1}{T} \quad f = \frac{1}{.026} \quad f = 38.2$ Hz

   b. When the laser is on the outside of the CD with a radius of 10 cm, what is the frequency of the spinning CD?

$v = 12$ m/s, $r = 10 \text{ cm} = 0.1$ m

① $v = \frac{2\pi r}{T} \quad 12 = \frac{2\pi(.1)}{T} \quad T = \frac{2\pi(.1)}{12} = 0.052$ s

② $f = \frac{1}{T} \quad f = \frac{1}{.052} \quad f = 19.1$ Hz

Linear Speed

Answers:

1. c) 942 m d) 3.1 m/s 2. a) 1.57 m/s b) twice

3. a) 1 s b) 0.628 m/s c) tangent to circle d) 1 Hz

4. a) 26.2 s b) it is constantly changing its direction, so its velocity is changing c) 0.038 Hz

5. a) 1.8 s b)0.52 m/s c) 0.174 m/s

6. a) 38.2 Hz b) 19.1 Hz