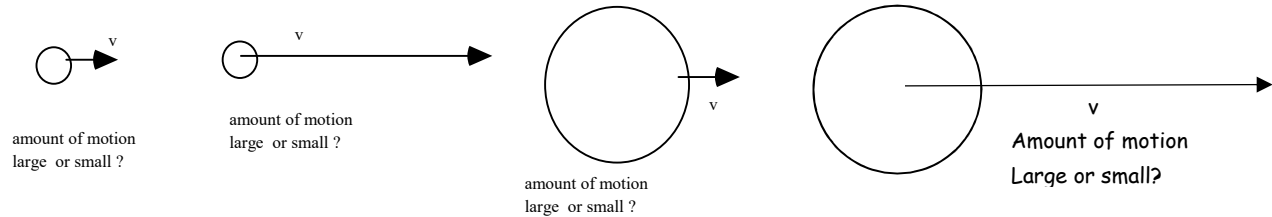


**Lesson 1: Momentum**

•momentum means 'the amount of motion an object has'.

•example 1: for each of the diagrams below, state whether the amount of motion is (comparatively) large or small



Explain your answer:

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•since momentum depends on both mass and speed, we call it the 'motion product' and use the letter p (for product). Momentum is a vector quantity; its direction is the same as the velocity vector. Here we can write a vector equation:

Momentum = mass x velocity

**p**=momentum=motion product (kg m/s)

**m**=mass (kg)

**v**= velocity (m/s)

•Note that a Newton second can also be used as a momentum unit:

- example 1:
- a) Estimate the magnitude of the momentum of a top pitcher's fastball
  - b) Estimate the magnitude of the momentum of a person & bicycle on a relaxed ride
  - c) Estimate the magnitude of the momentum of a car driving on a city street

	estimate mass	estimate speed	estimate momentum
fastball			
bike & rider			
car			

Ex 2: A baseball of mass 0.14 kg is moving at 35 m/s.

(a) Find the magnitude of the momentum of the baseball.

(b) Find the magnitude of the velocity at which a bowling ball, mass 7.26 kg, would have the same momentum as the baseball.

Ex. 3) A 12 kg rock is dropped from a 75 m high cliff. What is its momentum upon impact (magnitude and direction)?

**Lesson 1 Homework:**

1. The momentum of an object depends upon the object's \_\_\_\_\_. (Pick two quantities.)

- a. mass - how much stuff it has
- b. acceleration - the rate at which the stuff changes its velocity
- c. weight - the force by which gravity attracts the stuff to Earth
- d. velocity - how fast and in what direction it's stuff is moving
- e. position - where the stuff is at

(ans: a, d)

2. Momentum is a \_\_\_\_\_ quantity.                      a. scalar                      b. vector

(ans: b)

3. Which are complete, correct descriptions of the momentum of an object? Circle all that apply.

- a. 2.0 kg/s
- b. 7.2 kg·m/s, right
- c. 6.1 kg·m/s<sup>2</sup>, down
- d. 4.2 m/s, east
- e. 1.9 kg·m/s, west
- f. 2.3 kg·m/s

(ans: b, e)      Note: (f) is a momentum magnitude, but it's missing a direction

4. The two quantities needed to calculate an object's momentum are \_\_\_\_\_ and \_\_\_\_\_.

(see #1 for the answer)

5. Consider the mass and velocity values of Objects A and B below.

Compared to Object B, Object A has \_\_\_\_\_ momentum.

- a. two times the
- b. four times the
- c. eight times the
- d. the same
- e. one-half the
- f. one-fourth the
- g. ... impossible to tell without knowledge of the F and a.



Ans: a

6. Calculate the momentum of ... (Include appropriate units on your answers.)

a. ... a 2.0-kg brick moving through the air due west at 12 m/s.

b. ... a 3.5-kg wagon moving south along the sidewalk at 1.2 m/s.

(ans: 24 kg m/s West, 4.2 kg m/s South)

7. With what velocity must a 0.53-kg softball be moving to equal the momentum of a 0.31-kg baseball moving at 21 m/s? (12.3 m/s)

8. Calculate the momentum of a  $1.60 \times 10^3$  kg car traveling at West at 20.0 m/s.  
(32000 kg m/s west)

9. Calculate the momentum of a  $2.50 \times 10^3$  kg truck traveling north at 110 km/h.  
(76400 kg m/s north)

10. How fast is a 1.50 kg ball moving if it has a momentum of 4.50 kg m/s east?  
(3.0 m/s east)

11. A 75.0 g ball is rolling at a speed of 57.0 cm/s. Calculate the magnitude of the ball's momentum.  
(0.043 kg m/s ← check the units carefully!)

12. A 5.00 kg ball traveling at 6.0 m/s accelerates at a rate of  $2.00 \text{ m/s}^2$  for 1.50 seconds. Calculate the ball's momentum after the acceleration. (45 kg m/s)

13. A 2.00 kg rock is dropped from the top of a 30.0 m high building. Calculate the ball's momentum at the time that it strikes the ground. (-48.5 kg m/s or 48.5 kg m/s down)

14. A 1.50 kg rock is thrown up into the air from ground level, reaches a maximum height of 7.00 m, and then returns to the ground. Calculate the rock's momentum as it strikes the ground.  
(-17.6 kg m/s or 17.6 kg m/s down)