# Lesson 1 Momentum

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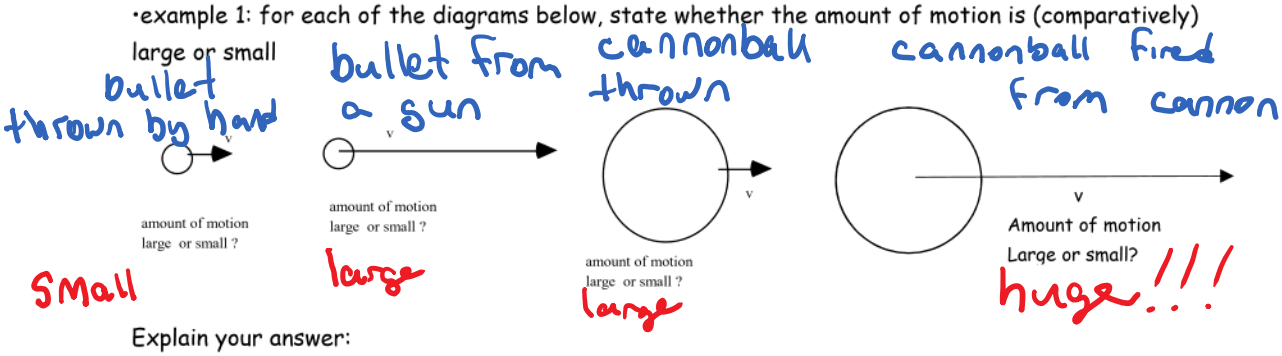
Physics 11 Unit 6 Momentum Name: _____

## 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:

_____

_____

_____

_____

•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

$\vec{p} = m\vec{v}$

$kg\ m/s$

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:

$N \cdot s = kg\ \frac{m}{s^2} \cdot s = kg\ m/s$

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•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 | 0.15 kg | ≈ 100 mph<br>40 m/s | 6 kg m/s | ouch! pain |
| bike & rider | 90 kg | 36 km/h<br>10 m/s | approx<br>1000 kg m/s | injury |
| car | 1000 kg | 100 km/h<br>approx<br>30 m/s | 30,000 kg m/s |  |



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.

a) $\vec{p} = m\vec{v} \simeq (.14)(35) = 4.9$ kg m/s

b) $\vec{p} = m\vec{v} \rightarrow \vec{v} \simeq \frac{\vec{p}}{m} = \frac{4.9}{7.26} = .675$ m/s

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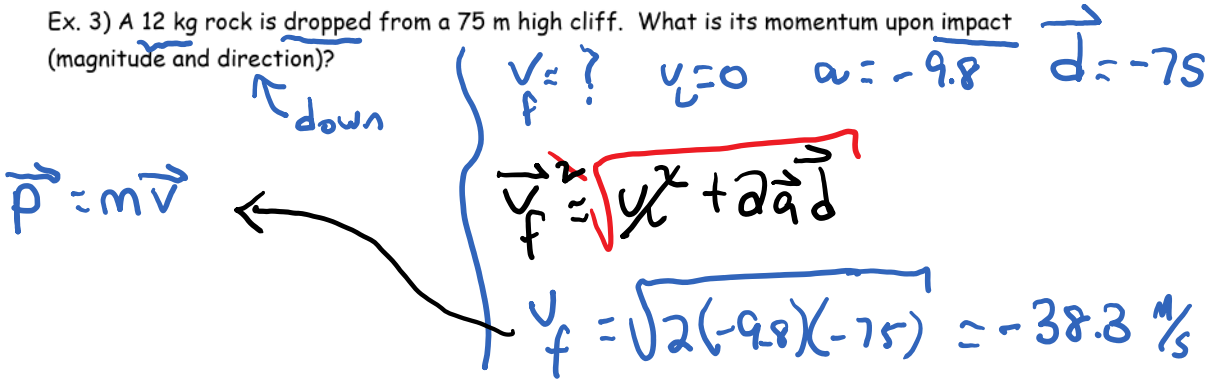
Ex. 3) A 12 kg rock is dropped from a 75 m high cliff. What is its momentum upon impact (magnitude and direction)?




$\vec{p} = (12)(38.3) = 460$ kg m/s down

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**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 <u>complete</u>, 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$^2$, 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

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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 $m/s^2$ 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)

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