**ANSWER KEY**

# L01 – Momentum and Net Force

Momentum: A vector quality of motion of a moving body, measured as a product of its mass and velocity, measured in Kilogram-Meters per Second (kg*m/s).

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

p = momentum ($kg\ m/s$)
m = mass ($kg$)
v = speed ($m/s$)

Force: A vector quantity measuring a push or a pull on an object; measured in Newtons (N *or* $kg*m/s^2$)

$\vec{F} = m\vec{a}$

F = Force ($kg\ m/s^2$)
m = mass ($kg$)
a = acceleration ($m/s^2$)

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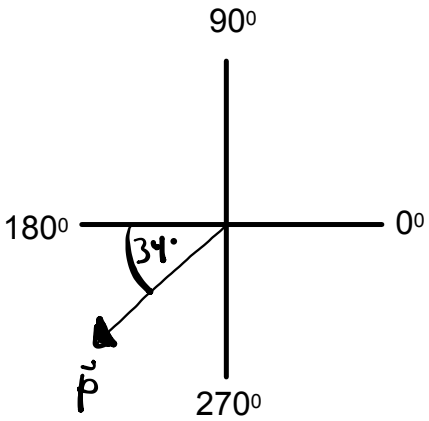
# Momentum is a Vector

**Q1:** A 425g soccer ball is rolling along the ground at 18.6 m/s [214$^0$].

(a) Draw a momentum vector diagram to represent the momentum of the soccer ball.




(b) Calculate the momentum of the soccer ball.

$m = 0.425 kg$

$\vec{v} = 18.6 m/s\ [214°]$

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

$= (0.425)(18.6)$

$= 7.905$

$\vec{p} = 7.905\ kg\,m/s\ [214°]$

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# Momentum is Dependent on Mass and Velocity

**Q2:** Which has more momentum, a Hummer H2 of mass 2900 kg travelling at 15 kph, or a Smart Fortwo of mass 730 kg travelling at 18 m/s?

2900 kg

$$\frac{15\ \text{km}}{\text{h}} * \frac{1000\text{m}}{1\text{km}} * \frac{1\text{h}}{3600\text{s}} = \frac{4.1\overline{6}\ \text{m}}{\text{s}}$$

$p = mv$
$= (2900)(4.1\overline{6})$
$= 12{,}083.\overline{3}\ \text{kgm/s}$

730 kg

18 m/s

$p = mv$
$= (730)(18)$
$= 13{,}140\ \text{kgm/s}$

This one has more momentum.

# Momentum is Dependent on Mass and Velocity

**Q3:** An object has a constant momentum of 2.45 x $10^2$ kg m/s [N]. Determine the momentum of the object if its mass decreases to 1/3 of its original value and an applied force causes the speed to increases by exactly four times.

Original

$p = 245 \text{ kg m/s}$

$p = mv$

New

$p_{new} = \left(\frac{1}{3}m\right)(4v)$

$= \frac{4}{3}mv$

$= \frac{4}{3}(245)$

$= 326.\bar{6} \text{ kg m/s}$

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# A Force can cause a Change in Momentum


Scroll Down

**Q4:** What is the purpose of automotive crumple zones, airbags, and seat belts?

To increase impact time.

$$\vec{F}_{net_{avg}} = \frac{\Delta\vec{p}}{\Delta t}$$

← Same change in momentum

← Larger time (denominator) means smaller force.

https://www.youtube.com/watch?v=jRbqpctO4rQ

Momentum will go to zero, so $\Delta\vec{p}$ is a fixed number.

Boxes increase time, so reduce force.