Momentum & Impulse

Momentum

1. Calculate the momentum of a 4.0 kg object traveling at a velocity of 12.0 m/s east.

$p = mv$
$= (4\text{kg})(12\text{m/s}) = 48\text{ kgm/s [E]}$

2. A 5.0 kg object has a momentum of 25.0 kgm/s west. What is its velocity?

$p = mv$ $\quad v = 5\text{ m/s [W]}$
$25\text{kgm/s} = 5\text{kg}(v)$

3. An object has a velocity of 8.0 m/s south and a momentum of 36.0 kgm/s south. What is its mass?

$p = mv$ $\quad m = 4.5\text{kg}$
$36\text{kgm/s} = m(8\text{m/s})$

4. An object has a velocity of 2.0 m/s east and a momentum of 29 kgm/s. What is the weight of the object?

$p = mv$ $\quad m = 14.5\text{kg}$
$29\text{kgm/s} = m(2\text{m/s})$ $\quad F_g = mg$
$= (14.5)(9.8) = 140\text{N}$

5. A 6.6 N object is traveling at a velocity of 3.0 m/s north. What is the object's momentum?

$F_g = mg$
$6.6\text{N} = m(9.8)$
$m = .67\text{kg}$

$p = mv$
$= (.67\text{kg})(3.0\text{m/s})$
$= 2.0\text{ kgm/s [N]}$

6. A 7.0 kg object travels 2.6 m west in 1.1 s. Assuming uniform velocity, what is the momentum of the object?

$v = \frac{\Delta d}{\Delta t} = \frac{2.6\text{m}}{1.1\text{s}}$
$= 2.36\text{m/s}$

$p = mv$
$= (7.0\text{kg})(2.36\text{m/s})$
$= 16.5\text{ kgm/s [W]}$

7. A 5.0 kg object is dropped from a height of 2.5 m above the floor. What is the object's momentum after 0.25 s?

$v_f = v_0 + at$
$= 0 + (9.8)(.25)$
$= 2.45\text{ m/s}$

$p = mv$
$= (5\text{kg})(2.45\text{m/s})$
$= 12.3\text{ kgm/s}$

8. A 1.0 kg ball hits the floor with a velocity of 2.0 m/s. If the ball bounces up with a velocity of 1.6 m/s, what is the ball's change in momentum?

$\Delta p = p_f - p_0$ $\quad = 3.6\text{ kgm/s [up]}$
$= mv_f - mv_0$
$= (1.0\text{kg})(1.6\text{m/s}) - (1.0\text{kg})(-2.0\text{m/s})$
$= 1.6\text{ kgm/s} + 2\text{ kgm/s}$

9. A 0.144 kg baseball is pitched horizontally at + 38 m/s. The batter hits a horizontal line drive at − 38 m/s (the opposite direction!). What is the ball's change in momentum?

$\Delta p = p_f - p_0$
$= (.144\text{kg})(-38\text{m/s}) + (.144)(+38\text{m/s})$
$= -10.9\text{ kgm/s}$

10. The 1205 kg physics dragster is traveling at 35 km/h east when it hits the gas and accelerates at 12.5 m/s^2 for 3.25 s. What is its change in momentum during this time?

$35\text{km/h} = 9.7\text{m/s}$
$v_f = v_0 + at$
$= 9.7 + (12.5\text{m/s}^2)(3.25\text{s})$
$= 50.3\text{ m/s}$

$\Delta p = p_f - p_0$
$= (1205)(50.3) - (1205)(9.7)$
$= 49000\text{ kgm/s}$

Impulse

1. A rocket at rest with a mass of 9.5×10^3 kg is acted on by an average net force of 1.5×10^5 N upwards for 15 s. What is the final velocity of the rocket?

$I = F\Delta t$
$= (1.5\times10^5 N)(15s)$
$= 2.25\times10^6 N\cdot s$

$I = m\Delta v$
$2.25\times10^6 = 9.5\times10^3(\Delta v)$
$\Delta v = 237 m/s$
$v_f = 237 m/s$

2. A 26.3 kg object is traveling at 21.0 m/s north. What average net force is required to bring this object to a stop in 2.60 s?

$F\Delta t = m\Delta v$
$F(2.6) = (26.3)(21 m/s)$
$F = 212 m/s\ [S]$

3. An average force of 31.6 N south is used to accelerate a 15.0 kg object uniformly from rest to 10.0 m/s. What is the change in momentum?

$\Delta p = m\Delta v$
$= (15 kg)(10 m/s)$
$= 150\ kg\,m/s$

4. An average net force of 25.0 N acts north on an object for 7.20×10^{-1} s. What is the change in momentum of the object?

$\Delta p = F\cdot\Delta t$
$= (25N)(.72s)$
$= 18\ N\cdot s\ [N]$

5. A 5.00 kg object accelerates uniformly from rest to a velocity of 15.0 m/s east. What is the change in momentum on the object?

$\Delta p = m\Delta v$
$= (5kg)(15-0)$
$= 75\ kg\,m/s\ [E]$

6. An average net force caused an 11.0 kg object to accelerate uniformly from rest. If this object travels 26.3 m west in 3.20 s, what is the change in momentum of the object?

$I = F\cdot\Delta t$
$= (ma)\Delta t$
$= (11)(5.14)(3.2)$
$= 180\ N\cdot s$

$d = v_0 t + \frac{1}{2}at^2$
$26.3m = 0 + \frac{1}{2}(a)(3.2)^2$
$a = 5.14 m/s^2$

7. A 1.30 kg object is dropped from a height of 6.5 m. How far did the object fall when its momentum is 6.0 kgm/s?

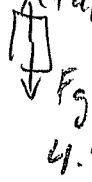
$p = mv$
$6.0 = 1.3(v)$
$v = 4.6 m/s$

$v_f^2 = v_0^2 + 2ad$
$4.6^2 = 0 + 2(9.8)d$
$d = 1.08 m$

8. An average net force of 16.0 N acts on an object for 2.00×10^{-1} s causing it to accelerate from rest to 3.50 m/s. What is the mass of the object?

$I = F\Delta t = m\Delta v$
$(16N)(.2s) = m(3.5 m/s)$
$m = .914\ kg$

9. A 0.500 kg object is thrown vertically upward with an average applied force of 8.20 N by a student. The force is applied through a displacement of 1.50 m.
   a. What is the average net force acting on the object?
   b. What is the velocity of the object when it leaves the student's hand? (Assume initial velocity is zero)



$F_{net} = F_{app} - F_g$
$= 8.2N - 4.9N$
$= 3.3N$

$a = \frac{F}{m} = \frac{3.3}{.5} = 6.6 m/s^2$

$v_f^2 = v_0^2 + 2ad$, $v_f = 4.4 m/s$