Physics-Based Animation (SET09119)

Tutorial 07 - Momentum & Impulses

1 Question

A 3kg mass has a velocity of $5ms^{-1}$. What is its momentum?

Momentum $= (3)(5) = 15Ns$

2 Question

A hockey ball of mass 0.2kg received an impulse of 1.2N at a free hit. With what speed does it begin to travel?

(0.2)(v) - (0.2)(0) = 1.2
therefore
v = 6
$\therefore$ Speed $6ms-1$

3 Question

In what time will a force of 8N reduce the speed of a particle of mass 3kg from $21ms^{-1}$ to $6ms^{-1}$

(3)(21) - (3)(6) = 8t
$\therefore$ t = 5.626 seconds

4 Question

A dart of mass 0.12kg, flying at a speed of $20ms^{-1}$ hits the dartboard and comes to a rest in 0.1 seconds. What is the average force exerted by the dartboard on the dart?

$(0.12)(20) = (F)(0.1)$
$\therefore F = 24N$

5   Question

A cup of 90 grammes is dropped from a height of 1.25m. What impulse force does it receive on striking the floor if it does not rebound?

$$
\begin{aligned}
v^2 &= u^2 + 2as \\
v^2 &= (0)^+ (2)(9.8)(1.25) \\
v &= \sqrt{(0)^+ (2)(9.8)(1.25)}
\end{aligned}
\tag{1}
$$

$\therefore$ v $= 4.95 \ ms^{-1}$

90g is 0.09kg

impulse = momentum after - momentum before

Impulse $= (0.09)(4.95) = 0.45N$

6   Question

A bullet is fired with a speed of $550ms^{-1}$ into a block of weed of mass 0.49kg, and becomes embedded in it. If it gives the block a speed of $11ms^{-1}$, find the mass of the bullet.

$(m)(550) = (0.49 + m)(11)$
$\therefore$ m $= 0.01$ kg

7   Question

A body of mass 8kg increases its speed from $4ms^{-1}$ to $6ms^{-1}$. What is the gain in kinetic energy?

Gain in KE $= \frac{1}{2}(8)(6^2) - \frac{1}{2}(8)(4^2) = 80J$

8 Question

A body of mass 225kg with a velocity of $4ms^{-1}$ strikes a body of mass 75 kg initially at rest. If the bodies move away together find:
(a) their common velocity,

$(225)(4) + (75)(0) = 300u$
$\therefore u = \frac{(225)(4)+(75)(0)}{300} = 3ms^{-1}$

(b) the total loss of kinetic energy during the impact.

$K.E. = \frac{1}{2}mv^2$

KE before $= (0.5)(225)(4^2) = 1800J$
KE after $= (0.5)(300)(3^2) = 1350J$
$\therefore$ Loss of KE $= 450J$

9 Question

A 4kg mass has a velocity vector (in ms^{-1}) of $3i + 4j$.
(a) What is the kinetic energy?
(b) What is the momentum?

(a) K.E. $= (0.5)(4)(3^2 + 4^2) = 50J$
(b) Momentum $= 4(3i + 4j) = 12i + 16j$ Ns

10 Question

An impulse has a magnitude of 20 Ns with direction vector 3i-4j. Express this impulse as a vector.

$||3 + 4|| = \sqrt{3^2 + 4^2} = 5$
We need to make the magnitude 20 - hence, we scale the direction vector by 4.
4(3i-4j) = (12i-16j) Ns
Note $||12i - 16j|| = 20$

Answer:
(12i-16j) Ns

11   Question

A 2kg mass with velocity vector (1.5i + 8j) ms^{-1} hits a 5kg mass with velocity vector (-2i+8j) ms^{-1}.
They coalesce and move off 'together'.
Find:
(a) their common velocity after the impact

momentum = (mass)(velocity)
The sum of momentums before collision should equal the sum of momentums after collision.
After the collision both objects combine into a single mass (i.e., 2+5 = 7kg).

$$2(1.5i + 8j) + 5(-2i + 8j) = 7V$$
$$V = (-i + 8j)ms^{-1}$$
(2)

i.e., after velocity = (-i+8j) ms^{-1}

(b) the total loss of kinetic energy

Loss of K.E. - sum of the kinetic energy before and after the collisions (i.e., $\frac{1}{2}mv^2$)

$$\big((0.5)(7)(1^2 + 8^2)\big) - \big((0.5)(2)(1.5^2 + 8^2) + (0.5)(5)(-2^2 + 8^2)\big)$$
$$227.5 - (236.25) = 8.75J$$
(3)

12   Question

A force has a magnitude 12.5N and acts in the 'direction' (7i+24j). Express this as a vector.

$||7i + 24j|| = 25$
$12.5 = (s)(25)$
s = (12.5)/(25) = 0.5

(0.5)(7i+24j) = (3.5i + 12j) N