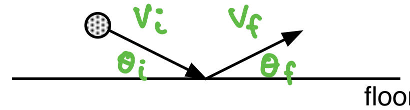
Momentum & Impulse

1. A 5.0 kg object with a speed of 30 m/s hits the floor at an angle of 45° and rebounds with the same speed and angle. What is the change (magnitude and direction) of the linear momentum of the ball (relative to the floor.)



$\vec{p}_i = m\vec{v}_i = 5(30\cos 45\,\hat{i} - 30\sin 45\,\hat{j})$

$= 106\hat{i} - 106\hat{j}$

$\vec{p}_f = m\vec{v}_f = 5(30\cos 45\,\hat{i} + 30\sin 45\,\hat{j})$

$= 106\hat{i} + 106\hat{j}$

$\Delta\vec{p} = \vec{p}_f - \vec{p}_i$

$= (106\hat{i} + 106\hat{j}) - (106\hat{i} - 106\hat{j})$

$\boxed{\Delta\vec{p} = 0\hat{i} + 212\hat{j} \text{ kg·m/s}}$

* See below for geometry version *

2. A 3 kg ball with an initial velocity of 15**i** m/s experiences an impulse of –20**i** + 30**j** Ns over a time interval of 0.04 seconds. What is the final velocity of the ball?

$m = 3\text{kg}$

$\vec{v}_i = 15\hat{i}$

$J = -20\hat{i} + 30\hat{j}$

$t = 0.04$

$J = \Delta p$

Notice "t" is not needed!!

$(-20\hat{i} + 30\hat{j}) = (3)\vec{v}_f - (3)(15\hat{i})$

$-20\hat{i} + 30\hat{j} = 3\vec{v}_f - 45\hat{i}$

$3\vec{v}_f = 25\hat{i} + 30\hat{j}$

$\boxed{\vec{v}_f = 8.3\hat{i} + 10\hat{j} \text{ m/s}}$

3. A super ball (mass = 0.035 kg) is thrown with a velocity of 15 m/s into a wall. It bounces back with a speed of 10 m/s. The ball and wall were in contact for only 0.02 seconds. What was the magnitude of the average force of the wall on the ball?

$m = 0.035$ kg

$v_i = 15$

$v_f = -10$ m/s (backwards!)

$t = 0.02$ s

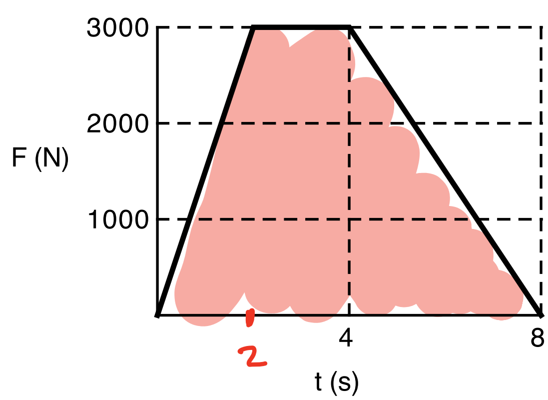
$J = \Delta p = mv_f - mv_i$

$F(.02) = (.035)(-10) - (.035)(15) =$

$F(.02) = -0.875$

$F = -43.75$ N $\rightarrow \therefore \boxed{|F| = 43.75 \text{ N}}$

4. A 1500 kg car traveling at 10 m/s somehow experiences a net force as shown in the diagram. (The force is in the direction that the car was moving.) What is the final speed of the car?



Area = J

$\text{Area} = J = \frac{1}{2}(2+8)(3000)$

$J = 15{,}000$ N·s

$J = \Delta p = mv_f - mv_i$

$mv_f = mv_i + J$

$(1500)v_f = (1500)(10) + 15{,}000$

$1500\,v_f = 30{,}000$

$\boxed{v_f = 20 \text{ m/s}}$

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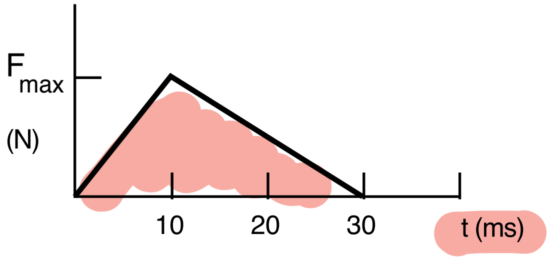
5. A tennis ball of mass 0.1 kg bounces off a wall. It had an original speed of 30 m/s and bounces straight backwards with a speed of 20 m/s. The magnitude of the force verses time graph showing the impulse of the wall on the tennis ball is shown. What was the maximum force on the tennis ball? (*Pay attention to the units on the graph.*)



$m = 0.1$ kg

$v_i = 30$ m/s

$v_f = -20$ m/s (backwards!)

∴ .01 .02 .03 seconds

($1 \text{ ms} = \frac{1}{1000}$ s)

Area = J

$= \frac{1}{2} F (.03)$

& $J = \Delta p$

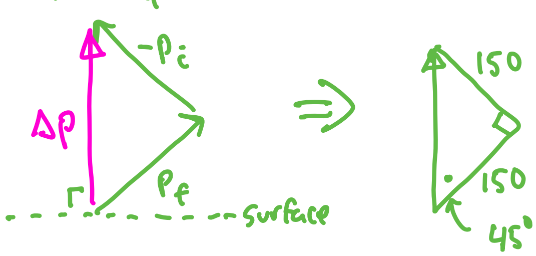
so $\frac{1}{2} F(.03) = (0.1)(-20) - (0.1)(30)$

$(.015)F = -2 - 3 = -5$

$F = -333$ N

$\boxed{\text{so } |F| = 333 \text{ N}}$

① $\Delta \vec{p} = \vec{p}_f - \vec{p}_i$



$\Delta p = \sqrt{150^2 + 150^2}$

$\Delta p = \sqrt{2}\ 150$

$\Delta p = 212$ kg-m/s

Answers:

1) 212 kg•m/s, ⊥ and away from surface *2) 8.3**i** + 10**j** m/s*

3) 43.75 N *4) 20 m/s* *5) 333 N*