General Physics 203, Section . . . Wednesday, June 17, 2015

Quiz #5

Name:

You can use any two lines (not parallel) as coordinate basis.

1) Linear Momentum

A fireworks rocket is moving at a speed of 45.0 m/s. The rocket suddenly breaks into two pieces of equal mass, which fly off with velocities $\mathbf{v}_1$ and $\mathbf{v}_2$, as shown in the fig. 1. What are the magnitudes of the velocities $\mathbf{v}_1$ and $\mathbf{v}_2$? **[1.0 pt]**

This is a verbatim copy of the problem 62, Chapter 7, Physics, by Cutnell & Johnson, 9th edition.

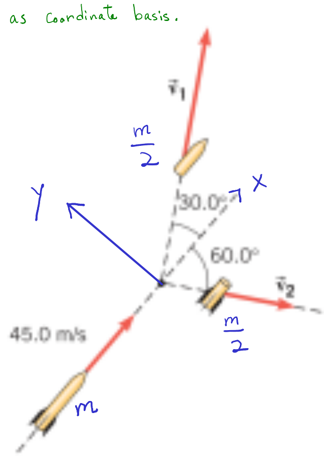


Figure 1: A rocket breaking to two equal mass parts.

There is no external force acting on the rocket during the time it breacks into pieces. So momentum of the rocket is conserved,

$\vec{F}_{ext} = 0 \rightarrow \vec{P} = \text{Const.}$ or $\vec{P}_f = \vec{P}_i$.

with the choice of coordinates drawn,

$P_{ix} = P_{f_x} \rightarrow m \cdot 45 \frac{m}{s} = \frac{m}{2} v_1 \cos 30° + \frac{m}{2} v_2 \cos 60°$ (i)

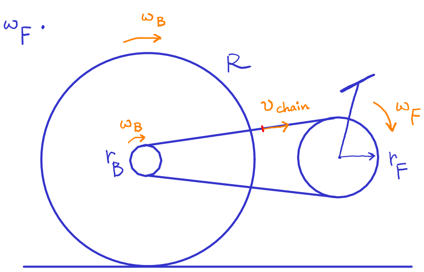
$P_{iy} = P_{f_y} \rightarrow 0 = \frac{m}{2} v_1 \sin 30° - \frac{m}{2} v_2 \sin 60°$ (ii)

(ii) $\rightarrow v_1 = v_2 \sqrt{3} \xrightarrow{(i)} \frac{3}{4} v_2 + \frac{1}{4} v_2 = 45 \frac{m}{s}$

$\rightarrow v_2 = 45 \frac{m}{s}$ & $v_1 = 78 \frac{m}{s}$.

2) Rotational Kinematics

You are riding a bike. At each time $T = 5$ s you are doing a total turn with pedals. The gear in front has radius $r_F = 15$ cm and the gear at the back has radius $r_B = 5$ cm. The radius of the wheels are $R = 30$ cm. There is no sliding involved. Find the velocity of the bike. **[1.0 pt]**



The angular velocity of the front gear and the pedals is the same, ω_F.

$T = 5\,s \rightarrow \omega_F = \frac{2\pi}{T} = \frac{2\pi}{5} \frac{rad}{s}$.

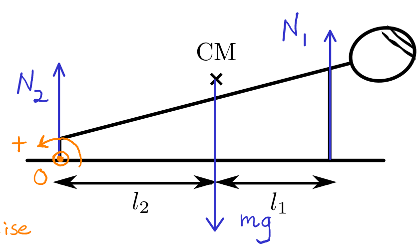
$v_{chain} = r_F \omega_F = r_B \omega_B \rightarrow \omega_B = \frac{r_F}{r_B} \omega_F = \frac{6\pi}{5} \frac{rad}{s}$.

The angular velocity of the back gear and the wheel is the same, ω_B. So, $v_{bike} = R \omega_B = 36\pi \frac{cm}{s} = 1.13 \frac{m}{s}$.

3) Rotational Dynamics

A person with mass $m = 70$ kg is doing push-ups. Holding the position as shown in fig. 2, find the normal force exerted by the floor on each hand and each foot. $l_1 = 0.41$ m and $l_2 = 0.84$ m. **[1.0 pt]**

This is a copy of the problem 12, Chapter 9, Physics, by Cutnell & Johnson, 9th edition.



Counter clockwise direction is the positive direction

Figure 2: A person doing push-up.

The person is at equilibrium

no acceleration : $\sum \vec{F} = 0$ (two eqn in 2D)

no angular acceleration : $\sum \tau_o = 0$ (one eq'n in 2D, you can choose any point O on the plane.)

$\sum F_x = 0 \rightarrow$ trivial.

$\sum F_y = 0 \rightarrow N_1 + N_2 - mg = 0$ (i)

$\sum \tau_o = 0 \rightarrow N_2 \cdot 0 - mg\, l_2 + N_1 (l_1 + l_2) = 0$ (ii)

(ii) $\rightarrow N_1 = mg \frac{l_2}{l_1 + l_2} = 461\ N$.

(i) $\rightarrow N_2 = mg \frac{l_1}{l_1 + l_2} = 225\ N$.

$F_{hand} = \frac{N_1}{2}$, $F_{foot} = \frac{N_2}{2}$.