University Physics 1A

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Practice Test Review

Example

Car A of mass 800kg and car B of mass 1200kg are headed towards each other as show (top view) Immediately before impact, car A has a speed of 30.0 m/s and makes an angle of 40° with the x-axis as shown. Car B has a speed of 20.0 m/s and makes an angle of 75° with the y-axis as shown. After the collision, the cars stick together and move as one. What is the velocity of the cars immediately after the collision, expressed in unit vector notation.

$$\begin{aligned} m_A\vec{v_A} + m_B\vec{v_B} &= (m_A + m_B)\vec{v_f} \\ (800)(30)(\cos(40)\hat{i} + \sin(40)\hat{j}) + (1200)(-20)(\sin(75)\hat{i} + \cos(75)\hat{j}) &= (800 + 1200)\vec{v_f} \\ \vec{v_f} &= -2.4\hat{i} + 10.8\hat{j} \end{aligned}$$

Is the collision elastic or inelastic?
Totally inelastic.

$$\begin{aligned} KE_i &= \frac{1}{2}m_A\vec{v_A}^2 + \frac{1}{2}m_B\vec{v_B}^2 \\ &= \frac{1}{2}(800)(30^2) + \frac{1}{2}(1200)(20^2) \\ &= 600000J \\ KE_f &= \frac{1}{2}(1200 + 800)(2.4^2 + 10.8^2) \\ &= 122400J \\ &\neq KE_i \end{aligned}$$

Example

A block of mass m starts from rest at the top of a frictionless hill of height H. It slides down the hill and then over another hill of height h. The top of the second smaller hill can be modeled as part of a circle with radius h. If $H = \frac{5h}{4}$, what is the normal force that the track exerts on the block when it is at the top of the second hill? Express your answer in terms of m and g.

$$\begin{aligned}
KE + PE &= 0 + mgh \\
&= \frac{1}{2}mv^2 + mgh \\
v^2 &= 2gH - 2gh \\
&= 2g(H - h) \\
F_{net} &= F_N - mg = -m\frac{v^2}{r} \\
F_N - mg &= -m\frac{v^2}{r} \\
&= -\frac{m}{h}(2g(H - h)) \\
F_N &= -\frac{m}{h}2g(H - h) + mg \\
&= mg(3 - 2\frac{H}{h}) \\
&= mg(3 - 2\frac{\frac{5}{4}h}{h}) \\
&= mg(3 - \frac{10}{4}) \\
&= \frac{1}{2}mg
\end{aligned}$$

Example

A block of mass m travels over a frictionless circular hill of radius and height R. At the top of the hill, the normal force on the moving block is found to be $\frac{mg}{4}$.

$$\begin{aligned} F_N - mg &= (\frac{1}{4} - 1)mg \\ &= -\frac{3}{4}mg \\ &= -m\frac{v_0^2}{R} \\ v_0^2 &= \frac{3}{4}gR \\ PE_i + KE_i + W_{friction} &= PE_f + KE_f \\ mgR + \frac{1}{2}mv_0^2 - \mu_k(4mg)d &= 0 \\ mgR(1 + \frac{3}{8}) &= \mu_k(mgd) \\ R(\frac{11}{8}) &= \mu_k 4d \\ d &= \frac{11R}{32\mu_k} \end{aligned}$$

Collisions

Inelastic Collision: $KE_f < KE_i$
Perfectly Elastic Collision: $KE_f = KE_i$
Superelastic Collision: $KE_f > KE_i$

Example

A raft is floating in the water. A scout stands on the end of a raft nearest the shore. He is 150.0m from shore, and the raft is 8.00m long. The mass of the scout is 90.0 kg and the mass of the raft is 500.0 kg. The scout walks to the other end of the raft.

How far is the scout from shore after he has walked to the far end?

$$\begin{aligned} x_{CoM\ initial} &= \frac{(90kg)(150m) + (500kg)(154m)}{500kg + 90kg} = 153.4m \\ x_{CoM\ final} &= x_{CoM\ initial} = 153.4m \\ &= \frac{(90)x_{scout} + 500x_{raft}}{590} \\ &= \frac{90x_{scout} + 500(x_{scout} - 4)}{590} \\ x_{scout} &= 156.8m \end{aligned}$$

You can find all my notes at `http://omgimanerd.tech/notes`. If you have any questions, comments, or concerns, please contact me at alvin@omgimanerd.tech