Phys 131 2024

Lecture 31

~~Ben:~~ Mon: HW due

Tues: Warm Up 12

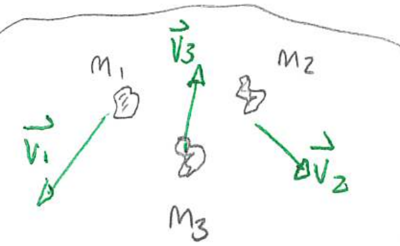
Weds: Review

Fri: Exam 3 * Energy + momentum
* Ch 9, 10, 11

2022, 2023 Exam 3 All questions

Conservation of momentum

The schematic for conservation of momentum is



Identify system of objects

→ Total momentum

$$\vec{p}_{tot} = \vec{p}_1 + \vec{p}_2 + \vec{p}_3 + \dots = m_1\vec{v}_1 + m_2\vec{v}_2 + m_3\vec{v}_3 + \dots$$

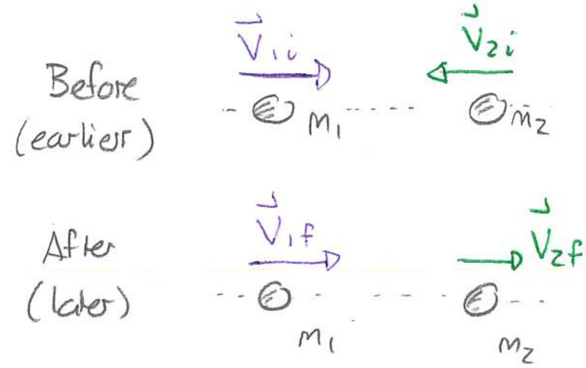
→ Identify external forces (exerted from outside the system)

→ If the net external force is zero then the total momentum is constant

$$\frac{d\vec{p}_{tot}}{dt} = 0$$

Note that the momentum of one part of the system can change as time passes, but this has to be offset against changes in other parts of the system.

For two objects in one dimension:



$$p_{tot\,f} = p_{tot\,i}$$

$$m_1 v_{1f} + m_2 v_{2f} = m_1 v_{1i} + m_2 v_{2i}$$

Any of the velocities could be positive or any could be negative. (Signs of velocities matter!)

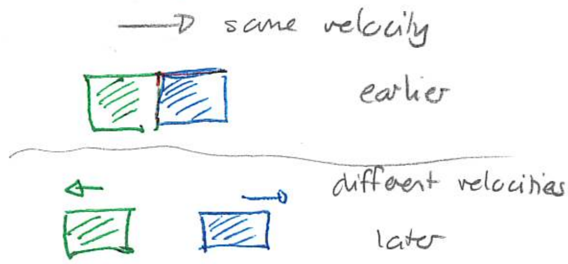
Quiz1 95% } 70% - 95%

Quiz2 5%-30% } 10% - 30%

DEMO: Happy / Sad Ball.

Explosions

An explosion is a situation where two objects that initially move together, separate and move apart.



Quiz3 50% - 95% } 95%

Quiz4 30% }

In these situations, both objects are initially at rest. Then momentum conservation gives:

$$m_1 v_{1f} + m_2 v_{2f} = \cancel{m_1 v_{1i}} + \cancel{m_2 v_{2i}} = 0$$

$$\Rightarrow \quad v_{2f} = -\frac{m_1}{m_2} v_{1f}$$

Then the ratio of masses is crucial. For earth and a person

person $m_1 = 100\,kg$

Earth $m_2 = 6.0 \times 10^{24}\,kg$

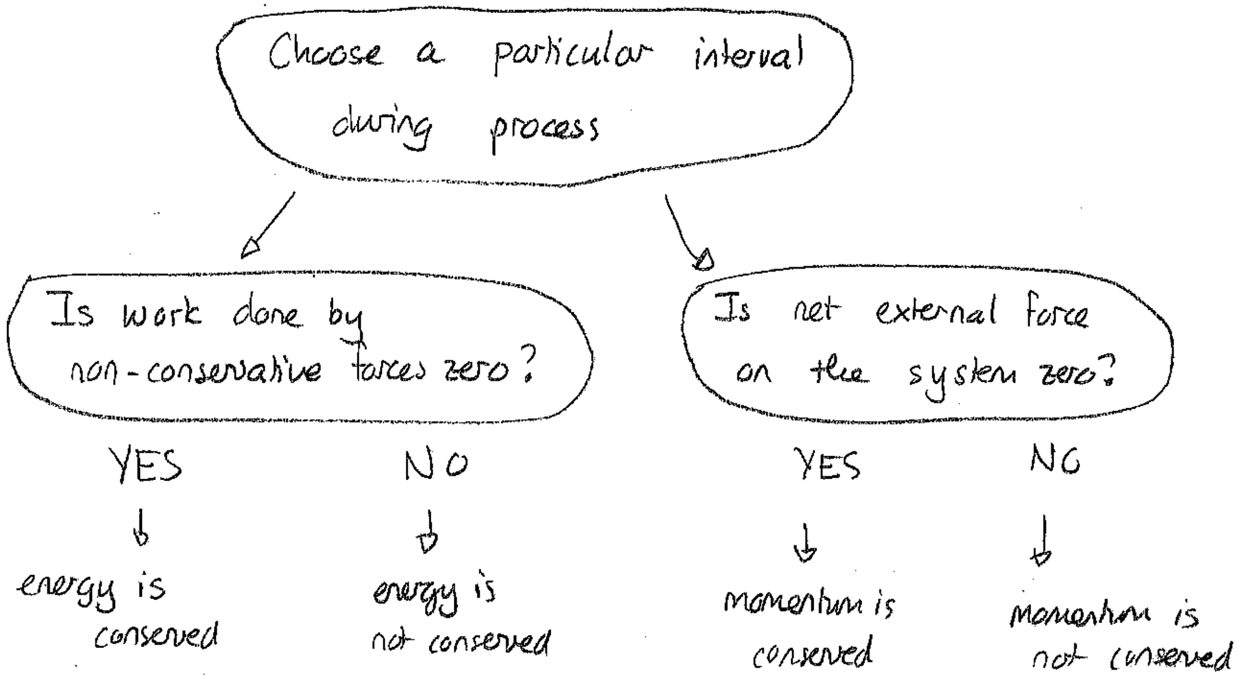
$$\Rightarrow \quad V_{Earth\,f} = -\frac{100\,kg}{6.0 \times 10^{24}\,kg} V_{person\,f}$$

$$V_{Earth\,f} = \underbrace{-1.7 \times 10^{-23}}_{\text{very small}} V_{person\,f}$$

DEMO: Taylor Swift concert.

Momentum and energy in collisions.

We can use either or both momentum and energy in collisions.



Fundamental Mechanics: Group Exercise 7

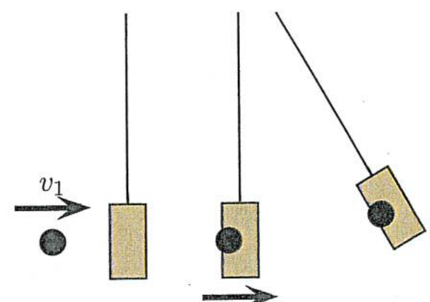
14 April 2023

Names: ______________ ______________ ______________

______________ ______________

1 Ballistic pendulum

A ballistic pendulum consists of a 1.5 kg wooden block suspended at rest from a cord. A 0.0080 kg bullet is fired horizontally into the block. It embeds itself causing the block to swing upward, reaching a point 0.20 m above its lowest point. The idea is to use the maximum height reached by the pendulum to determine the speed of the bullet immediately before hitting the block. The process is illustrated at three instants. Let instant 1 be the moment just before the bullet hits, instant 2, the moment just after it embeds and instant 3, the moment at which it reaches its highest point. *(131Sp2023)*



a) Is momentum conserved from instant 1 to instant 2? Is mechanical energy, $E = K + U_{\text{grav}}$, conserved from instant 1 to instant 2?

b) Is momentum conserved from instant 2 to instant 3? Is mechanical energy, $E = K + U_{\text{grav}}$, conserved from instant 2 to instant 3?

c) Consider the period from instant 2 to instant 3 and use this to determine the speed of the bullet and block just after it embeds.

d) Consider the period from instant 1 to instant 2 and use this to determine the speed of the bullet and block just before it embeds.

a) From 1 to 2 friction does non-zero work ⇒ energy not conserved
net external force = 0 ⇒ momentum conserved

b) From 2 to 3 non-conservative force tension does zero work ⇒ energy conserved
net external force (gravity, tension) ≠ 0 ⇒ momentum not conserved

c)

mass = $M_{wood} + M_{bullet} = M$

$V_2 = ?$ $\quad V_3 = 0\,m/s$

$y_2 = 0$ $\quad y_3 = h$

$E_f = E_i$

$K_f + U_{gf} = K_i + U_{gi}$

$\frac{1}{2} M V_3^2 + M g y_3 = \frac{1}{2} M V_2^2 + M g y_2$

$\Rightarrow V_2^2 = 2gh \Rightarrow V_2 = \sqrt{2gh}$

$\Rightarrow V_2 = \sqrt{2 \times 9.8\,m/s^2 \times 0.20\,m}$

$= 1.98\,m/s$

d)

initial

$V_{bi} = V_1$ $\quad V_{wi} = 0$

final

$V_{bf} = V_{wf} = V_2$

Momentum conserved

$p_{tot\,f} = p_{tot\,i}$

$M_b V_{bf} + M_w V_{wf} = M_b V_{bi} + M_w V_{wi}$ (0)

$\Rightarrow (M_b + M_w) V_2 = M_b V_1$

$\Rightarrow V_1 = \frac{M_b + M_w}{M_b} V_2 = \frac{1.508\,kg}{0.008\,kg} 1.98\,m/s$

$V_1 = 373\,m/s$