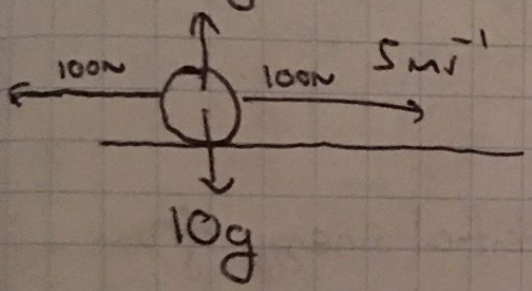
3. A book is at height 6m and is dropped. If the book is 2kg, what is the final speed of the book before it hits the ground?

Tutoring Lesson Notes : Lesson 2:

Quick Review!

REMEMBER: $E_K = \frac{1}{2}mv^2$ and $E_g = mgh$

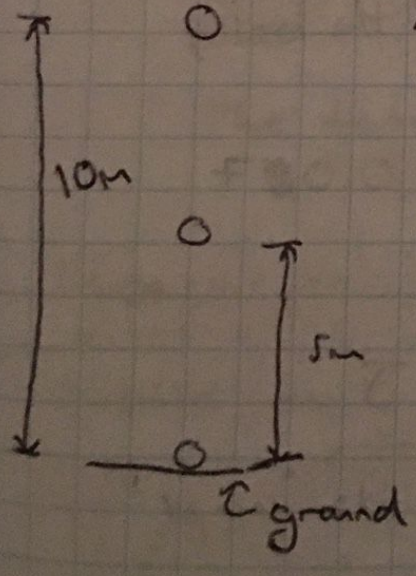
Total mechanical energy ($E_K + E_g$) is conserved (... assuming no friction)



→ forces are equal, so velocity constant

$E_K = \frac{1}{2} \cdot 10 \cdot 5^2 = 125J$

Consider a ball falling of mass 1kg

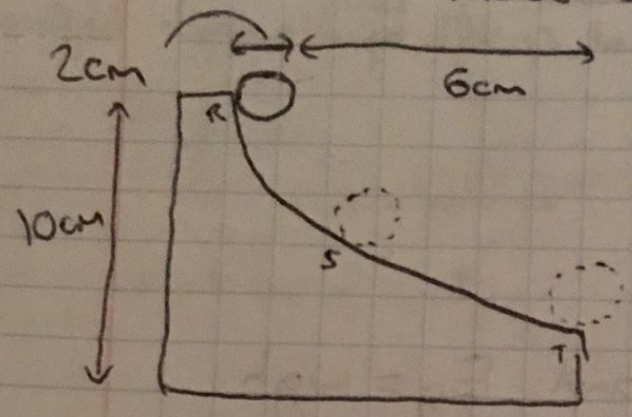


At A: $E_K = 0$ (as $v=0$)
$E_g = 1 \cdot g \cdot 10 = 98.1J$ (~ 100J)

At B: $E_K + E_g = 100$J
$E_g = 1 \cdot g \cdot 5 \approx 50J$
$\Rightarrow E_K = 100 - 50 = 50J$
$\Rightarrow \frac{1}{2} \cdot 1 \cdot v^2 = 50J$
$\Rightarrow v = \sqrt{100} = 10 ms^{-1}$

At C: $E_g = 0$ (as $h=0$)
$\Rightarrow E_K = 100J$
$\Rightarrow \frac{1}{2} \cdot 1 \cdot v^2 = 100 \Rightarrow v = \sqrt{200}\ ms^{-1}$

• GAMSAT 2008 Sample Q7-9:



ball: $r = 1cm$
$m = 50g$

Assume no friction

$R_{RST} = 8cm$

7) As the ball slides down the surface from R to T, the total mechanical energy:

Answer: Remains constant

8) The decrease in gravitational potential energy from R to T is closest to:

Answer: Note that $h = 7cm$ (as we are told that the radius of RST is 8cm then subtract the radius of the ball)

Thus the change is $E_g = mgh$

$= 0.05 \cdot 10 \cdot 0.07$

$= 0.035$

$= 3.5 \times 10^{-2} J$

[Don't forget! We work in kg and m!]

Quick guide to standard form, count the jumps!

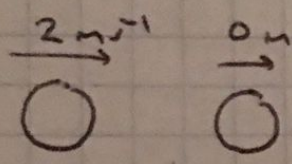
0.0 3 5 → 2 jumps to the right (-)
$\Rightarrow 3.5 \times 10^{-2}$

9 0 0 0 0 → 4 jumps to the left (+)
$\Rightarrow 9 \times 10^{4}$

9) If the slide slot is now free to slide on the table, and the ball slides again from R to T, what happens to the total mechanical energy of the ball?

Answer: Decreases! Careful, the total mechanical energy of the whole system is unchanged (i.e: the ball AND the slide slot). But as the ball rolls, some of its energy is given to the slide slot so that it moves.

How to think of this:



Suppose a ball of $m = 1kg$ hits a ball of $m = 9kg$ that isn't moving.

The end result is both balls moving

→ the first ball has lost kinetic energy (and thus mechanical energy) while the second ball has gained them.

The total mechanical energy will still be the same!

MOMENTUM:

Momentum is the mass times the velocity:

$$p = mv$$

In the absence of external forces:

MOMENTUM IS CONSERVED

1. A man of mass 100 kg runs at $8 ms^{-1}$. What is his momentum?

$$p = 100 \cdot 8 = 800 \text{ kg } ms^{-1}$$

2. An object of mass 5kg and $v = 100 ms^{-1}$ explodes in two parts. One of these parts is of mass 3kg and moves $50 ms^{-1}$ in the same direction as the original object. If the other part also moves in the same direction, what is its velocity?

$$p = 5 \cdot 100 = 500 \text{ kg } ms^{-1} \quad \text{(Momentum conserved)}$$

$$p_1 = 3 \cdot 50 = 150 \text{ kg } ms^{-1}$$

$$p_2 = 500 - 150 = 350 \text{ kg } ms^{-1}$$

$$\Rightarrow 350 = 2 \cdot v$$

$$\underline{v = 175 ms^{-1}}$$

Definitions:

- Elastic collision – Kinetic energy is conserved in the collision
- Inelastic collision – Kinetic energy is not conserved

3. For Q2 above, is this elastic or inelastic?

$$E_{k,start} = \frac{1}{2} \cdot 5 \cdot 100^2 = 25000 \text{ J}$$

$$E_{k,final} = \frac{1}{2} \cdot 2 \cdot 175^2 + \frac{1}{2} \cdot 3 \cdot 150^2$$

$$= 64375 \text{ J}$$

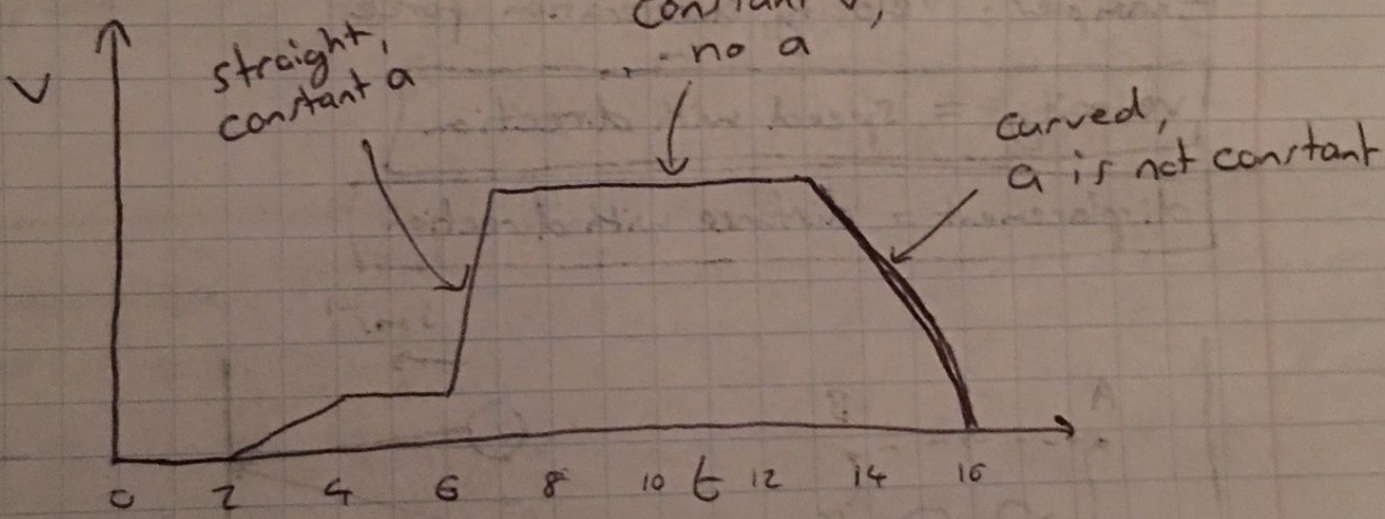
Why is this inelastic?

↳ explosion: chemical energy converted into kinetic energy.

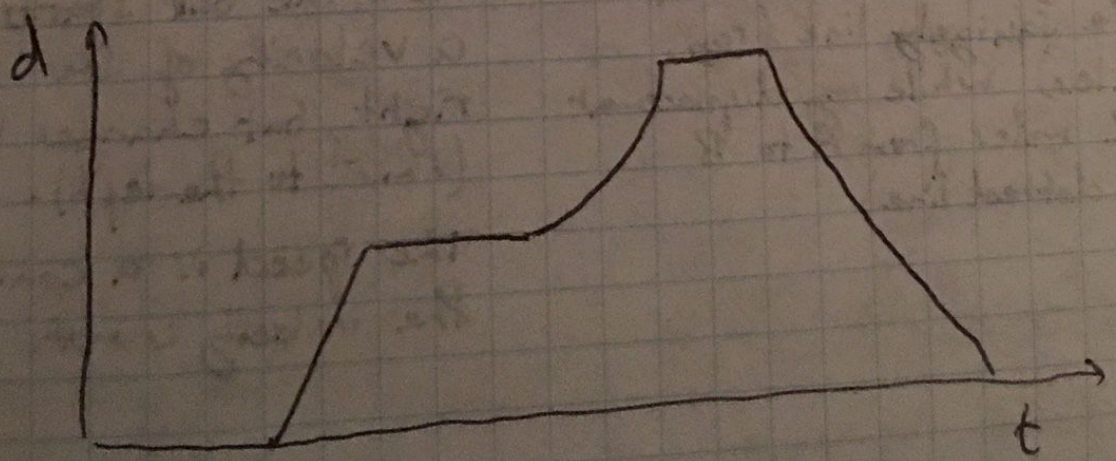
Chemical energy is another type of potential energy, and so total mechanical energy is still conserved.

Graphs:

- Velocity - Time:



- ~~Displacement~~ Displacement - time



Questions:

1. If a bumper car (A) of mass 105 kg and velocity $2 ms^{-1}$ hits a stationary bumper car B of mass 50 kg, and A comes to a halt upon the collision:

   a) What is the velocity of B after the collision?

   b) Is this collision elastic?

2. Suppose a train is travelling at $50 ms^{-1}$ east. If the train changes direction but maintains the same speed, which of the following will change?

   a) Momentum
   b) Kinetic energy
   c) velocity
   d) displacement
   e) Total mechanical energy

   [there may be more than one answer here!]

[Hint: Which are vectors and which are scalars?]