

Examples of Kinetic Energy Problems.

The Kinetic Energy (E_k) of an object depends on both its mass (m) **and** its speed (v).

You must be able to

- carry out calculations involving the relationship between Kinetic Energy, mass and speed.
(You need to be able to use the equation $E_k = \frac{1}{2}mv^2$)
- carry out calculations involving energy, work, power and the principle of conservation of energy.
(You can be asked to solve problems similar to the lift example we looked at in class)

The examples in this handout are designed to help prepare you for the extended style of problems that can appear in the credit paper, since this is where any questions involving calculations about Kinetic Energy will appear in the May exams.

This first example involves the change in Kinetic Energy when an object accelerates.

Example:

A rocket of mass 1.5×10^4 kg accelerates at 220 ms^{-2} for 29s from an initial speed of 5200 ms^{-1} .

(a) How fast will be rocket be travelling after the 29s?

Solution:

Use

$$a = \frac{v - u}{t}$$

t = time = 29s

a = acceleration = 220 ms^{-2}

v = final speed = ?

u = initial speed = 5200 ms^{-1}

and rearrange to get an equation for v

$$v - u = at$$

$$v = u + at$$

$$= 5200 + (220 \times 29)$$

$$= 5200 + 6380$$

so

$$\underline{v = 11580 \text{ ms}^{-1}}$$

(b) How much Kinetic Energy has the rocket gained?

Solution:

Calculate the kinetic energy of the rocket both before and after the acceleration and work out the difference.

Use $E_k = \frac{1}{2}mv^2$

Initial Kinetic Energy: using $E_k = \frac{1}{2}mv^2$

$$= 0.5 \times (1.5 \times 10^4) \times (5200)^2$$

$$= 2.028 \times 10^{11} \text{ J}$$

PTO for rest of solution \longrightarrow

(continued from previous page)

Final Kinetic Energy: using $E_k = \frac{1}{2}mv^2$

$$= 0.5 \times (1.5 \times 10^4) \times (11580)^2$$

$$= 1.006 \times 10^{12} \text{ J}$$

so

Kinetic Energy gained = final E_k - initial E_k

$$= (1.006 \times 10^{12}) - (2.028 \times 10^{11})$$

$$= \underline{8.032 \times 10^{11} \text{ J}}$$

- (c) If the rocket is in space and the engine is then switched off, what will happen to the rocket speed?
Explain your answer.

Solution:

Think back to Newton's 1st Law. This tells us

"An object will stay at rest or travel at a constant speed if the forces acting on the object are balanced."

So

- If the rocket engine is switched off, there is no longer an unbalanced force, i.e. the forces on the rocket are balanced.
- Since the rocket is in space, there is no air resistance to slow it down.

This means that the rocket will continue to travel at a constant speed of 11580 ms^{-1} .

This final example uses the **conservation of energy**.

In questions like these, use both the kinetic energy **and** the potential energy of an object to solve the problem.

It is a good idea to show your working at each step of the problem as you rearrange the equation.

Example:

A lump of ice falls from an aeroplane as it comes in to land. If the ice hits the ground with a vertical speed of 85 ms^{-1} , what was the height of the plane when the ice fell off? (Assume that friction can be ignored.)

Solution:

Kinetic energy of the ice as it hits the ground is equal to the initial potential energy when it fell off the plane.

So $E_p = E_k$

But $E_p = mgh$ and $E_k = \frac{1}{2}mv^2$

So

$mgh = \frac{1}{2}mv^2$ ← this is the same as saying $E_p = E_k$

$gh = \frac{1}{2}v^2$ ← m is on both sides of the equation so we can remove it

$2gh = v^2$

$h = \frac{v^2}{2g} = \frac{85^2}{2 \times 9.8} = 368.6\text{m}$

The ice fell from the plane at a height of 370 m (2 sig figs).

Notice how we did not even need to know the mass of the ice to solve this problem!