Potential energy, mechanical energy and conservation of mechanical energy

Starter

1. To jump start Olivia's old car, of mass 700 kg, she needs to get it rolling at 1 m/s. She always parks it on a slight initial incline so that when she releases the hand brake, the car moves off at 0.2 m/s. The resistance to motion is 400 N. Given that the average person can push with a force of 120 N, calculate the minimum number of people needed to push the car from the bottom of the slight incline in order to get it started before the main road which is 50 m away.

Notes

Gravitational potential energy

Gravitational potential energy is the energy an object has due to its position (usually its distance above the ground).

Gravitational potential energy $= mgh$ where h is usually the height above ground level

E.g. 1 A mountaineer of mass 65 kg scales a peak 3.2 km high. Calculate her gain in potential energy.

Principle of conservation of mechanical energy

If the only force acting on an object is gravitational then GPE + KE = a constant.

Consider a ball thrown into the air.

At the start the ball has an initial velocity which means it has KE. It is normal to take the ground as the GPE $= 0$ point.

Between the ground and the highest point the ball has both KE and GPE.

At the top of the motion, the ball is instantaneously at rest so has no KE. At this point, the ball only has GPE.

3. No KE, just GPE
2. KE and GPE
1. No GPE, just KE

N.B. Any point can be chosen as the "GPE $= 0$" point. The GPE is calculated relative to this point.

E.g. 2 A stone of mass 0.8 kg is thrown vertically upwards with speed 10 m/s. By considering energy, calculate the initial kinetic energy and the height to which the stone will rise.

Working:

Initial KE $= \frac{1}{2} \times 0.8 \times 10^2 = 40$

Gain in GPE = Loss in KE: $0.8gh = 40$

$$h = \frac{50}{g} \approx 5.10$$

The initial kinetic energy is 40 J and the height to which the stone will rise is 5.10 m (3 s.f.)

E.g. 3 A particle of mass 2 kg falls freely from rest. Calculate the kinetic energy of the particle after it has descended 20 m and hence its velocity

Work energy principle revisited

WD by driving force — WD against resistive forces = Change in mechanical energy

where mechanical energy = GPE + KE

Think of driving forces adding energy into the model and resistive forces taking away energy from the model.

WD by driving forces + Initial KE + Initial GPE = WD against resistive forces + Final GPE + Final KE

E.g. 4 A skier of mass 70 kg sets off with initial speed of 5 m/s down a hill of constant slope, inclined at $20°$ to the horizontal. The hill is 80 m long.

(a) Ignoring resistive forces forces, calculate the speed of the skier at the bottom of the slope.

(b) If instead the skier reaches the bottom with a speed of 6 m/s, calculate the magnitude of the constant resistive forces.

Video: Gravitational potential energy

Work-energy principle EQ

Solutions to Starter and E.g.s

Exercise

p12 1C Qu 1-10

Summary

Gravitational potential energy = mgh where h is usually the height above ground level

Principle of conservation of mechanical energy: **GPE + KE = a constant**

WD by driving force — WD against resistive forces = Change in mechanical energy, where mechanical energy = GPE + KE

Think of driving forces adding energy into the model and resistive forces taking away energy from the model.

WD by driving forces + Initial KE + Initial GPE = WD against resistive forces + Final GPE + Final KE