Lecture 19

Fri: Read 6.3 → 6.6

HW by 5pm

Thurs: Seminar 12:30 pm WS 160

Energy conservation

For systems that move primarily under Earth's gravity the Law of Conservation of Energy gives:

Total energy is constant ⇒ stays same at all times.

↓

Total energy = kinetic energy + potential energy

Kinetic energy = $\frac{1}{2} \times (\text{mass}) \times (\text{speed})^2$

Potential energy = $(\text{mass}) \times 9.8 \times (\text{height})$

DEMO: PhET Energy Skate Park

* Use measurement tab
* human

Quiz1 90% ~ 100%

Quiz2 50% ~ 70%

Quiz3 60% → 80%

Using energy to predict motion

What use is the energy bookkeeping system? We can use it to predict aspects of motion.

If we can find out the kinetic energy at any instant, then we can find the speed. The formula involves getting

$$(\text{speed})^2 = \frac{2 \times (\text{kinetic energy})}{\text{mass}}$$

and once we have $(\text{speed})^2$ we can get the speed by taking a square root.

Derivation:

$$KE = \frac{1}{2} M \times v^2 \quad \Rightarrow \quad 2\,KE = \underbrace{2 \times \frac{1}{2}}_{1} \times M \times v^2$$

$$\frac{2KE}{M} = \frac{M \times v^2}{M}$$

$$\Rightarrow \quad \frac{2KE}{M} = v^2 \quad \Rightarrow \quad v^2 = \frac{2KE}{M}$$

Then $v = \sqrt{\frac{2KE}{M}}$

1 Skating cat

A skating cat with mass 10 kg is held at rest at the top of a ramp, whose height is 10 m above the ground. The skating cat is released and slides down the ramp. The aim of this exercise will be to find the speed of the skating cat at the bottom of the ramp.

You can use the table beneath to record the information about the energies.

a) Determine the potential and kinetic energies of the cat at the instant at which it is released.

b) Determine the potential and kinetic energies of the cat at the instant at the moment at which it reaches the ground.

c) Determine the speed of the cat at the instant at the moment at which it reaches the ground.

Instant	KE	PE	Energy
Initially	0J	980J	980J
At ground	980J	0J	980J

same!

Answers: a) $PE = \text{mass} \times 9.8 \times \text{height} = 10 \times 9.8 \times 10 = 980\,J$

$KE = \frac{1}{2} \times \text{mass} \times (\text{speed})^2 = \frac{1}{2} \times 10 \times (0)^2 = 0\,J$

$\Rightarrow E = PE + KE = 980\,J$

b) $PE = \text{mass} \times 9.8 \times \text{height} = 10 \times 9.8 \times 0 = 0\,J$

$KE = E - PE = 980\,J - 0\,J = 980\,J$

All potential energy converted into KE.

c) $KE = \frac{1}{2} \times \text{mass} \times (\text{speed})^2$

$980\,J = \frac{1}{2} \times 10\,kg \times (\text{speed})^2$

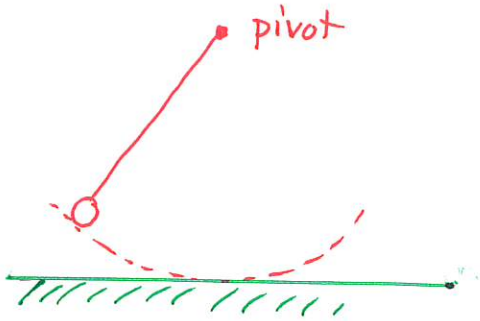
$980\,J = 5\,kg \times (\text{speed})^2$

$(\text{speed})^2 = \frac{980\,J}{5\,kg} = 196$

$\Rightarrow \text{speed} = \sqrt{196} = 14\,m/s$

Pendulum and Energy

The Law of Conservation of Energy also applies to a pendulum.



This is an object that swings under the influence of Earth's gravity. Note that, at the highest point speed = 0 and KE = 0

Quiz 3 50% - 90%

DEMO: Stopped Pendulum

2 Swinging pendulum

A pendulum with mass 0.20 kg is released from rest. At the lowest point of its swing the pendulum is moves with speed 2.0 m/s. The aim of this exercise will be to find the maximum height reached by the pendulum.

You can use the table beneath to record the information about the energies.

a) Determine the potential, kinetic and total energies of the pendulum at the lowest point of its swing.

b) Determine the potential, kinetic and total energies of the pendulum at the instant at which it reaches its highest point.

c) Determine the maximum height that the pendulum reaches.

Instant	KE	PE	Energy
At lowest point	0.40J	0 J	0.40J
At max height	0 J	0.40J	0.40J

a) $KE = \frac{1}{2} \times (\text{mass}) \times (\text{speed})^2 = \frac{1}{2} \times 0.20 \times (2.0)^2 = 0.40\text{J}$

$PE = 0$ since height $= 0$

$E = KE + PE = 0.40\text{J}$

b) $KE = 0\text{J}$ since speed $= 0$

$\Rightarrow PE = 0.40\text{J}$

c) $PE = \text{mass} \times 9.8 \times \text{height}$

$0.40\text{J} = 0.20 \times 9.8 \times \text{height}$

$= 1.96 \times \text{height}$

$\text{height} = \frac{0.40\text{J}}{1.96} = 0.20\text{m}$