CAPS

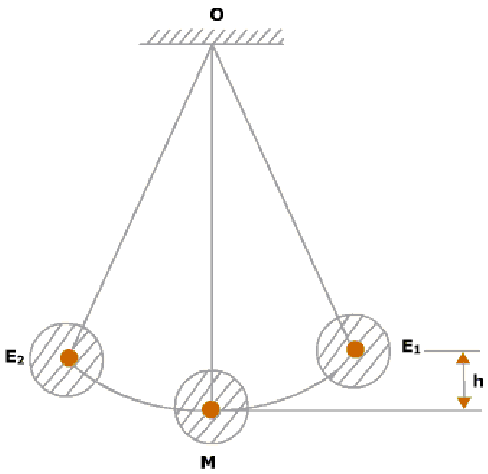
A Guide to Energy

Teaching Approach

At the grade 10 level learners already have a good idea about energy. Start this section by revising the different types of energy and emphasize that all different kinds of energy can either be classified as kinetic energy or potential energy.

It is very important that the teacher only look at the concept of energy, and not link it to work done since that is not required in the CAPS document.

Show an experiment to illustrate the conservation of mechanical energy. You can show a simple pendulum experiment with a mass piece on a string.



Vibrating simple pendulum

Alternatively the following experiment can be done as prescribed in the CAPS document.

Materials

A length of plastic pipe with diameter approximately 20 mm, a marble, some masking tape and a measuring tape.

To do (1)

First put one end of the pipe on the table top so that it is parallel to the top of the table and tape it in position with the masking tape.

Lift the other end of the pipe upwards and hold it at a steady height not too high above the table.

Measure the vertical height from the table top to the top opening of the pipe.

Now put the marble at the top of the pipe and let it go so that it travels through the pipe and out the other end.

Questions

mindset

- What is the velocity (i.e. fast, slow, not moving) of the marble when you first put it into the top of the pipe and what does this mean for its gravitational potential and kinetic energy?
- What is the velocity (i.e. fast, slow, not moving) of the marble when it reaches the other end of the pipe and rolls onto the desk? What does this mean for its gravitational potential and kinetic energy?

To do (2)

Now lift the top of the pipe as high as it will go.

Measure the vertical height of the top of the pipe above the table top.

Put the marble into the top opening and let it roll through the pipe onto the table.

Questions

- What is the velocity (i.e. fast, slow, not moving) of the marble when you put it into the top of the pipe, and what does this mean for its gravitational potential and kinetic energy?
- Compared to the first attempt, what was different about the height of the top of the tube? How do you think this affects the gravitational potential energy of the marble?
- Compared to your first attempt, was the marble moving faster or slower when it came out of the bottom of the pipe the second time? What does this mean for the kinetic energy of the marble?
    - The activity with the marble rolling down the pipe shows very nicely the conversion between gravitational potential energy and kinetic energy. In the first instance, the pipe was held relatively low and therefore the gravitational potential energy was also relatively low. The kinetic energy at this point was zero since the marble wasn't moving yet. When the marble rolled out of the other end of the pipe, it was moving relatively slowly, and therefore its kinetic energy was also relatively low. At this point its gravitational potential energy was zero since it was at zero height above the table top.
    - In the second instance, the marble started off higher up and therefore its gravitational potential energy was higher. By the time it got to the bottom of the pipe, its gravitational potential energy was zero (zero height above the table) but its kinetic energy was high since it was moving much faster than the first time. Therefore, the gravitational potential energy was converted completely to kinetic energy (if we ignore friction with the pipe).
    - In the case of the pipe being held higher, the gravitational potential energy at the start was higher, and the kinetic energy (and velocity) of the marble was higher at the end. In other words, the total mechanical energy was higher and only depended on

the height you held the pipe above the table top and not on the distance the marble had to travel through the pipe.

Please make sure to stress to learners that this section is revisited in Grade 12 and therefore it is very important that the concepts are properly understood.

Video Summaries

Some videos have a 'PAUSE' moment, at which point the teacher or learner can choose to pause the video and try to answer the question posed or calculate the answer to the problem under discussion. Once the video starts again, the answer to the question or the right answer to the calculation is given.

Mindset suggests a number of ways to use the video lessons. These include:

- Watch or show a lesson as an introduction to a lesson
- Watch or show a lesson after a lesson, as a summary or as a way of adding in some interesting real-life applications or practical aspects
- Design a worksheet or set of questions about one video lesson. Then ask learners to watch a video related to the lesson and to complete the worksheet or questions, either in groups or individually
- Worksheets and questions based on video lessons can be used as short assessments or exercises
- Ask learners to watch a particular video lesson for homework (in the school library or on the website, depending on how the material is available) as preparation for the next day's lesson; if desired, learners can be given specific questions to answer in preparation for the next day's lesson

1. Potential and Kinetic Energy

In this video we look at different types of energy and focus specifically on gravitational potential energy and kinetic energy and we also do calculations with the given equations.

2. Mechanical Energy

Mechanical energy is the sum of gravitational potential energy and kinetic energy. In this lesson we define mechanical energy, and so some calculations with the formulae.

3. Conservation of Mechanical Energy

What is the law of conservation of energy and how does energy stay conserved? In the third lesson of the series we look at this law of energy and then we look at the application of the principle of conservation of mechanical energy to various contexts.

Resource Material

1. Potential and Kinetic Energy	http://en.wikipedia.org/wiki/Potential_energy	Potential energy
	http://en.wikipedia.org/wiki/Kinetic_energy	Kinetic energy
	http://www.mrwaynesclass.com/energy/WS2006/home.html	Worksheet on E_k and E_p
2. Mechanical energy	http://www.physicsclassroom.com/mmedia/energy/pe.cfm	Definition and pendulum simulation
	http://www.universetoday.com/73598/what-is-mechanical-energy/	Examples of mechanical energy
	https://www.youtube.com/watch?v=HNkqy-qsheY	You tube examples
3. **Conservation of mechanical energy**	http://m.everythingscience.co.za/grade-10/22-mechanical-energy/22-mechanical-energy-05.cnxmlplus	The experiment with a clear pipe
	http://theteterszone.net/handouts/energywksts.pdf	Worksheet with additional questions

Task

Question 1

A crane gradually lifts a car with a mass of 1000 kg at constant speed to a height of 5 m. Calculate the potential energy of the car at that height.

Question 2

A trolley and a sandbag have a combined mass of 4 kg. A bullet with a mass of 150 g is fired towards the trolley and is lodged in the sandbag. Immediately after the collision, the trolley and sandbag in combination with the bullet move backwards at 5,3 m·s^{-1}. Calculate the kinetic energy of the trolley, with the sandbag and bullet, directly after the collision.

Question 3

A toy car with a mass of 2 kg is at rest. A horizontal force is applied to the trolley and it starts to move in the direction of the applied force at 4 m·s^{-1}. Calculate the kinetic energy of the toy car after it has experienced this force.

Question 4

When a plane descends from its cruising height to land on a runway, 78 400 00 J of gravitational potential energy is transferred. If the mass of the plane is 40 000 kg, what was the cruising altitude of the plane before its descent?

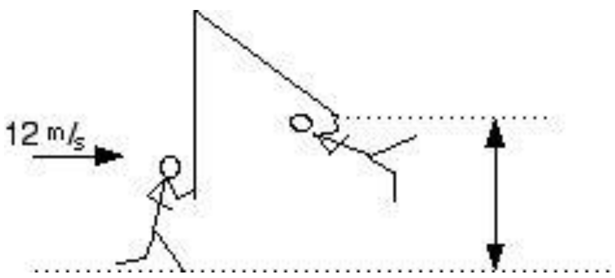
Question 5

A pot plant falls off the balcony of an apartment. The balcony is 20 m above the ground and the pot plant has a mass of 2 kg. After falling a distance of 2 m from the balcony, the pot plant has a velocity of 6,26 m·s^{-1}. Ignore the effect of air resistance.

5.1 Calculate the gravitational potential energy of the pot plant before it begins to fall.
5.2 Calculate the total mechanical energy of the pot plant after it has fallen two meters.
5.3 Is this a closed system? Explain your answer.
5.4 Calculate the speed with which the pot plant hits the ground.

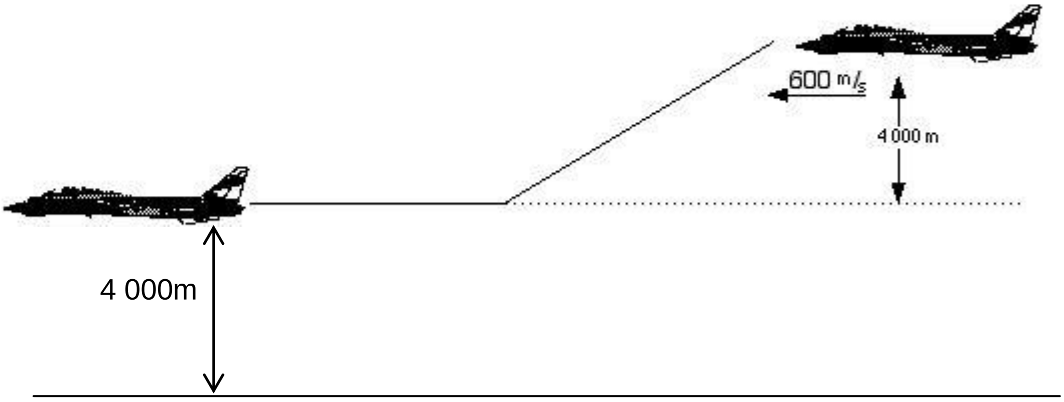
Question 6

Tarzan (m = 80 kg) is on a quest to save Jane. He runs towards a rope with a velocity of 12 m·s^{-1}. He grabs onto the rope. To what height will Tarzan swing?



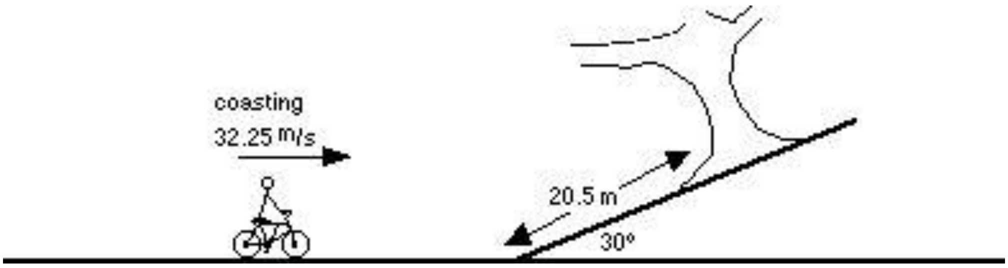
Question 7

A jet pilot flying at 600 m·s^{-1} is flying in clear space. The pilot decides to drop 4 000 m in altitude to a new altitude 4 000 m above the ground. What is the jet's new velocity if it descends to its new altitude? Air resistance can be ignored.



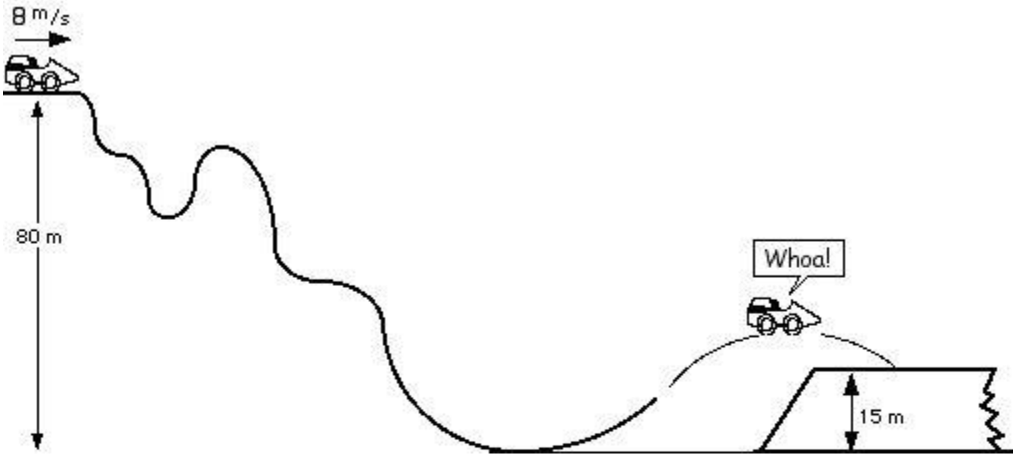
Question 8

A cyclist with a mass of 55 kg coasts on level ground at 32,25 m·s^{-1} . He free wheels up an incline of 30° to the horizontal and grabs an overhanging tree branch. What is the velocity of the cyclist when he grabs the branch?



Question 9

A roller coaster car, 500 kg, starting at a point 80 m above the lowest point of the track. The car travels from 8 m·s^{-1} down the steep track. There is no friction.



9.1 What is the total energy of the roller coaster car at the top of the track

9.2 What is the total energy of the system at the base of the rollercoaster track?

9.3 What is the velocity of the car at a height of 30 m from the base of the roller coaster track?

9.4 What is the velocity of the car at the base of the roller coaster track?

Task Answers

Question 1

E_P = mgh
= 1 000 x 9,8 x 5
= 49 000 J

Question 2

E_K = $\frac{1}{2}mv^2$
= $\frac{1}{2}(4,15)(5,3)^2$
= 58,29 J

Question 3

There is a change in velocity therefore:

ΔE_k = $\frac{1}{2}mv_f^{\ 2} - \frac{1}{2}mv_i^{\ 2}$
= $\frac{1}{2}(2)(4)^2 - \frac{1}{2}(2)(0)^2$
= 16 – 0
= 16 J

Question 4

E_P = mgh
78 400 000 = (40 000)(9,8) h
h = 200 m

Question 5

5.1 E_p =mgh
E_p = (2)(9,8)(20)
E_p = 392 J

5.2 $E_M = E_p + E_k$
$E_M = mgh + \frac{1}{2}mv^2$
$E_M = (2)(9,8)(18) + \frac{1}{2}(2)(6,26)^2$
E_M = 352,8 + 39,1876
E_M = 391,9876
E_M = 392,00 J

5.3 Yes it is a closed system since the energy is conserved and air resistance can be ignored.

5.4 Mechanical energy $_{top}$ = Mechanical energy $_{bottom}$
$(mgh + \frac{1}{2}mv^2)_{top} = (mgh + \frac{1}{2}mv^2)_{bottom}$
$392 = (2)(9,8)(0) + \frac{1}{2}(2)v^2$
v = 19,798989
v = 19,80 $m \cdot s^{-1}$

Question 6

$E_{M\ top} = E_{M\ bottom}$
$(E_p + E_k)_{top} = (E_p + E_k)_{bottom}$
$mgh + \frac{1}{2}mv^2 = mgh + \frac{1}{2}mv^2$
$80(9,8)h + \frac{1}{2}(80)(0)^2 = 80(9,8)0 + \frac{1}{2}(80)(12)^2$
h = 7,35 m

Question 7

$E_{M\ top} = E_{M\ bottom}$
$(E_p + E_k)_{top} = (E_p + E_k)_{bottom}$
$mgh + ½mv^2 = mgh + ½mv^2$
$m(9,8)(8000) + ½(m)(600)^2 = m(9,8)4000 + ½(m)v^2$
since the mass stays constant it can cancel out
$(9,8)(8000) + ½(600)^2 = 9,8(4000) + ½v^2$
$½v^2 = 219\ 200$
$v = \sqrt{2x219}\ 200$
$v = 662,12\ m{\cdot}s^{-1}$

Question 8

$E_{M\ top} = E_{M\ bottom}$
$(E_p + E_k)_{top} = (E_p + E_k)_{bottom}$
$mgh + ½mv^2 = mgh + ½mv^2$
$55(9,8)(20,5\sin 30°) + ½(55)v^2 = 55(9,8)0 + ½(55)(32,25)^2$
$v = 28,97\ m{\cdot}s^{-1}$

Question 9

9.1 $E_M = E_p + E_k$
$E_M = mgh + ½mv^2$
$E_M = (500)(9,8)(80) + ½(500)(8)^2$
$E_M = 408\ 000J$

9.2 $E_{M\ top} = E_{M\ bottom}$
So $E_{M\ bottom} = 408\ 000J$

9.3 $E_{M\ top} = E_{M\ bottom}$
$408\ 00 = (E_p + E_k)_{bottom}$
$408\ 000 = mgh + ½mv^2$
$408\ 000 = 500(9,8)30 + ½(500)v^2$
$v^2 = 1044$
$v = 32,31\ m{\cdot}s^{-1}$

9.4 $E_{M\ top} = E_{M\ bottom}$
$408\ 00 = (E_p + E_k)_{bottom}$
$408\ 000 = mgh + ½mv^2$
$408\ 000 = 500(9,8)0 + ½(500)v^2$
$v^2 = 1\ 632$
$v = 40,40\ m{\cdot}s^{-1}$

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