SUVA SANGAM COLLEGE
YEAR 12
PHYSICS

WEEK 1
MONDAY: 05/07/2021 - FRIDAY: 09/07/2021

STRAND	**P12.2** ENERGY
SUB-STRAND	**P12.2.1** ENERGY TRANSFORMATION
CONTENT LEARNING OUTCOME	**P12.2.1.1** Relate transformations between energy in systems to the law of conservation of energy
REFERENCE FROM TEXT	**Pg 75 - 86**

Achievement Indicators

- Describe mechanical energy quantitatively as the sum of kinetic and potential energy

ENERGY, WORKDONE AND POWER

WORKDONE

- is the product of force and distance

$\boldsymbol{W = F \times d}$ where W = work done (J),
F = force (N),
d = distance (m)

Note: F and d must be parallel

POWER

- Is the rate of doing work

$$power = \frac{workdone\ (J)}{time\ taken\ (s)}$$
$$= J/s \ or \ watts\ (W)$$

ENERGY

Is the capacity of doing work i.e. stored work e.g. kinetic/potential/heat energy

Potential Energy

- **Gravitational potential energy** is the **energy** stored in an object as the result of its vertical position or height.
- Energy is transferred from **chemical energy** to **gravitational potential energy (PE)**

$$\boldsymbol{gravitational\ P.E = mgh}$$
$$unit = Joules$$
$$h = verticle\ height$$

Kinetic Energy

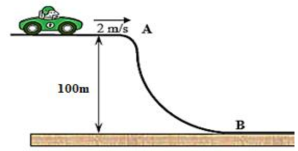
- Is the energy in a body possesses because it is moving
- A body of mass (m) moving with a velocity (v) has kinetic energy

$\boldsymbol{K.E = 1/2\ mv^2}$ unit = Joules (J)

- In physical sciences, **mechanical energy** is the **sum** of **potential energy** and **kinetic energy**.

Example 1

1. The diagram below shows a 0.5kg toy car being released from point A where its velocity is 2m/s. It moves down a frictionless track to B where its velocity is 10m/s



(i) Identify the type of energy present at A

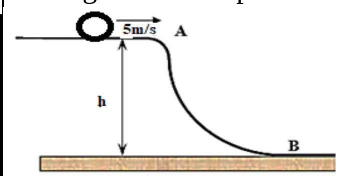
Mechanical Energy since the car is at a height and is moving

(ii) Calculate total energy at A

$$\boldsymbol{M.A = PE + K.E}$$
$$= mgh + \frac{1}{2}mv^2 = 0.5 \times 10 \times 100 + \frac{1}{2} \times 0.5 \times 2^2$$
$$= 500 + 1 = \boldsymbol{501J}$$

Example 2

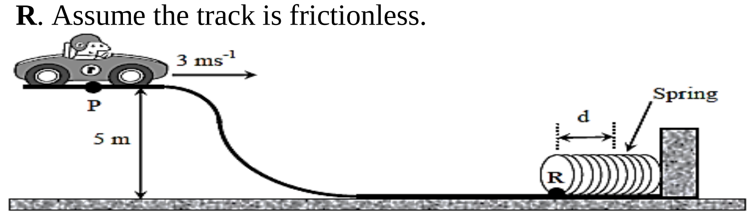
A 2kg ball rolls off a slope with a velocity of 5m/s. Calculate the height of the slope if the total mechanical energy at A is 40J



$$\boldsymbol{M.A = PE + K.E}$$
$$= mgh + \frac{1}{2}mv^2$$
$$40 = 2 \times 10 \times h + \frac{1}{2} \times 2 \times 5^2$$
$$40 = 20h + 25$$
$$40 - 25 = 20h$$
$$\frac{15}{20} = \boldsymbol{h = 0.75m}$$

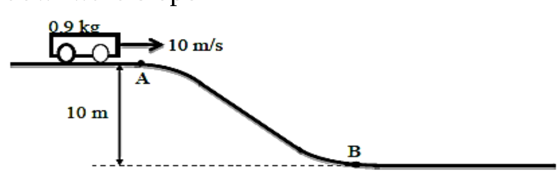
Exercises

1. The diagram given below shows a 0.8 kg toy car being released from point **P** at a height of 5 m where its velocity is 3 m/s. A spring with spring constant 100 Nm-1 is used to slow the toy car and to stop it at distance, d, from point **R**. Assume the track is frictionless.



(i) Name the type of energy present at P
(ii) Calculate kinetic energy at P
(iii) Calculate potential energy at P
(iv) Calculate total energy at P

2. Define mechanical energy.
3. A trolley of mass 0.9kg moves at 10m/s until it comes to a downward slope



Calculate:

(i) Potential energy at A
(ii) Kinetic energy at A
(iii) Mechanical energy at A

WEEK 2

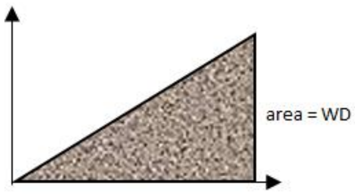
MONDAY: 12/07/2021 - FRIDAY: 16/07/2021

Achievement Indicators

- Apply the law of conservation of energy to solve energy problems

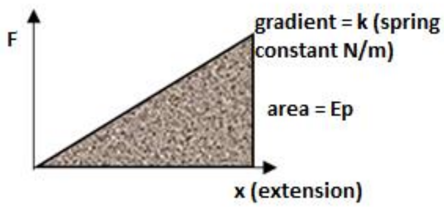
Force/distance curves

$work = area\ under \frac{F}{D}\ curve$



Energy in a spring – elastic potential energy

$Ep = \frac{1}{2}kx^2$



Hook's Law

$F = kx$

$F \propto x$

CONSERVATION OF ENERGY

- In all situations where work is done, energy is transferred from one form to another.
- Sometimes the energy is transferred into several forms of energy, such as heat, sound and light.
- This means that energy can be created but cannot be destroyed or lost, can only be conserved to other forms of energy **- law of conservation of energy**
- This means that a system always has the same amount of energy, unless it's added from the outside.

Example 1

A body of mass 20kg is dropped from a height of 15m.

a. Identify the type of energy present:

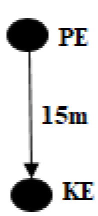
(i) Before the ball was dropped

Potential energy

(ii) As the ball reaches the ground

Kinetic energy

b. What is its velocity as it reaches the ground?



Law of conservation of energy

$$PE = KE$$

$$mgh = \frac{1}{2}mv^2$$

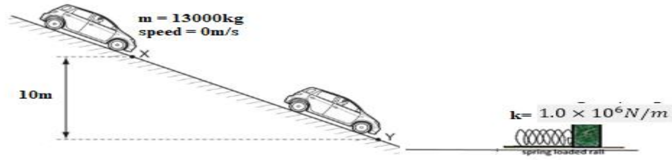
$$(20)(10)(15) = \frac{1}{2}(20)v^2$$

$$3000 = 10v^2$$

$$\sqrt{\left(\frac{3000}{10}\right)} = v = 17.32m/s$$

Example 2

1. A 13000kg car rolls from rest down a slope from a height from 10m. It then moves on a frictionless level surface and collides, with a light spring loaded rail that has a spring constant of $1.0 \times 10^6 N/m$



Neglecting any friction effects

(i) Calculate the speed of the car just before it collides with the rail

law of conservation of energy : $KE = PE$

$= mgh = 13000 \times 10 \times 10 = 1300000J$

(i) Determine the maximum distance that the spring is compressed

law of conservation of energy : $KE = EP = \frac{1}{2}kx^2$

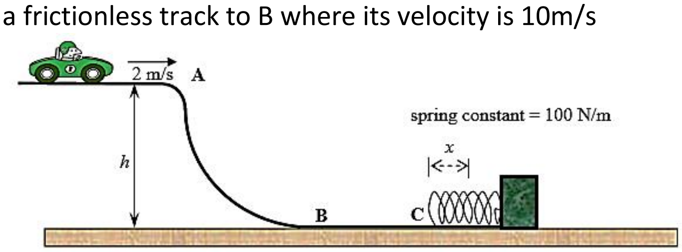
$$1300000 = \frac{1}{2}(1.0 \times 10^6)x^2$$

$$1300000 = 500000x^2$$

$$\sqrt{\left(\frac{1300000}{500000}\right)} = x = 1.61m$$

Exercises

1. A 2kg mass slides from a height of 0.5m on a frictionless surface and compressed a spring of a force constant 100N/kg on a horizontal
   (i) What is the speed of the mass just before it compresses the spring?
   (ii) How far will the spring be compressed when the mass comes to rest?
2. The diagram below shows a 0.5kg toy car being released from point A where its velocity is 2m/s. It moves down a frictionless track to B where its velocity is 10m/s



(i) Calculate the total energy at B

(ii) Find the height, h, from which the toy car was released.

(iii) A spring with spring constant 100N/m is used to show the toy car and stop it some distance x from point C. Calculate the distance x.

3. The law of conservation of energy states that
   A. For a body at rest, total momentum = 0
   B. For a moving body, work done is equal to Ek.
   C. Energy before collision = Energy after collision
   D. Energy is neither created nor destroyed it only changes its form.

WEEK 3

MONDAY: 19/07/2021 - FRIDAY: 23/07/2021

Achievement Indicators

- Apply the law of conservation of energy to solve energy problems

HEAT AND TEMPERATURE

Heat and temperature go hand in hand: the hotter something is the greater its temperature.

Heat

- Heat energy is a measure of the sum of kinetic and potential energy in all the molecules or atoms in an object.
- It is the amount of energy contained by all particles in a body

Temperature

- Temperature is a physical quantity which measures the degree of hotness of an object.
- It is a measure of the average kinetic energy which each molecule of an object possesses.

SPECIFIC HEAT CAPACITY (c)

- The amount of heat that must be supplied to increase the temperature by 1 °C for a mass of 1 kg of the substance
- Specific heat capacity, c SI unit: = J/ kg°C
- $\boldsymbol{Q = mc\Delta T}$

Where Q = heat energy absorbed/released (J)
m = mass (kg)
c = specific heat capacity of the substance (J/ kg°C)
ΔT = change in temperature $(T_f - T_i)$

Note: negative sign means heat is lost while positive means heat is gained

Converting Degrees Celsius to Kelvin Temperature

$\boldsymbol{K} = ℃ + \mathbf{273}$

Example

How much energy is required to raise 100g of water from 10℃ to boil? (c of water = 4200J/kg^{0}C)

$m = 100g = 0.1kg, T_i = 10 + 273 = 283K,$
$T_f = 100 + 273 = 373K$

$Q = \boldsymbol{mc}\Delta\boldsymbol{T} = (\mathbf{0.1})(\mathbf{4200})(\mathbf{373} - \mathbf{283}) = \mathbf{37800J}$

CONSERVATION OF ENERGY

When two substances come in contact and are prevented from losing heat to their surrounding then the heat lost from the hotter substance is equal to the heat gained by the colder substance

$$\boldsymbol{HEAT\ LOST\ IN\ A = HEAT\ GAINED\ BY\ B}$$

Example 1

A 600g metal of 100℃ is placed in a 300g of water at29℃. The final temperature of water and the metal is36℃. Taking c of water =4200J/kg℃, find the specific heat capacity of the metal.

Step 1: list all the information given

Metal	water
$m = 600g = 0.6kgm$	$m = 300g = 0.3kg$
$T_i = 100℃$	$T_i = 29℃$
$T_f = 36℃$	$T_f = 36℃$
$c = ???$	$c = 4200J/kg$

Step 2: plug into formula and solve for the unknown

$HEAT\ LOST\ IN\ METAL = HEAT\ GAINED\ BY\ WATER$

$$-mc\Delta T = mc\Delta T$$
$$-[(0.6)(c)(36 - 100)] = (0.3)(4200)(36 - 29)$$
$$38.4c = 8820$$
$$c = \frac{8820}{38.4} = \mathbf{229.69J/kg}℃$$

Example 2

A 80g metal of 85℃ is placed in a 20g of water at19℃. The final temperature of water and the metal is24℃. Taking c of water =4200J/kg℃, find the specific heat capacity of the metal.

Step 1: list all the information given

Metal	water
$m = 80g = 0.08kgm$	$m = 20g = 0.02kg$
$T_i = 85℃$	$T_i = 19℃$
$T_f = 24℃$	$T_f = 24℃$
$c = ???$	$c = 4200J/kg$

Step 2: plug into formula and solve for the unknown

$HEAT\ LOST\ IN\ METAL = HEAT\ GAINED\ BY\ WATER$

$$-mc\Delta T = mc\Delta T$$
$$-[(0.08)(c)(24 - 85)] = (0.02)(4200)(24 - 19)$$
$$4.88c = 420$$
$$c = \frac{420}{4.88} = \mathbf{86.07J/kg}℃$$

Exercise

1. Apiece of aluminium of mass 0.5kg is heated to 100℃ and then placed in a 0.4kg of water at 10℃. If the resulting temperature of the mixture is 30℃. What is the specific heat capacity of aluminium if c of water =4200J/kg℃?

2. Container x containing 2kg of water at 30℃ is poured into a container y with 3kg of water at 80℃. Assuming the specific heat capacity of water is unknown and there is no heat loss to the surrounding, calculate the final temperature of water.

3. A 6kg metal of 100℃ is placed in a 500g of water at15℃. The final temperature of water and the metal is27℃. Taking c of water =4200J/kg℃, find the specific heat capacity of the metal.

WEEK 4

MONDAY: 26/07/2021 - FRIDAY: 30/07/2021

Achievement indicator:

- Apply the law of conservation of energy to solve energy problems

SPECIFIC LATENT HEAT

- Unit: J kg-1
- The amount of heat required to change the phase of 1 kg of the substance at a constant temperature
- $\boxed{Q = mL}$

Where:

Q = heat absorbed or released by the substance

m = mass of the substance

L = latent heat

Specific latent heat of fusion (*Lf*)

- The amount of heat required to change 1 kg of the substance from **solid to liquid phase (melt)** or from **liquid to solid phase (freeze/solidify**) without a change in temperature.
- Example $L_f\ of\ ice = 340000 J/kg$
- $\boxed{Q = mL_f}$

Example

Find the amount of heat energy needed to melt 10g of ice?

Note: change mass into kg

$$Q = mL_f = \left(\frac{10}{1000}\right)(340000) = \mathbf{3400J}$$

Specific latent heat of vaporization (*Lv*)

- The amount of heat required to change 1 kg of the substance from the **liquid to gaseous** phase (vaporize) or from **gas to liquid** phase (condense) without a change in temperature
- example $L_v\ of\ water = 2.26 \times 10^6 J/kg$
- $\boxed{Q = mL_v}$

Example

Find the amount of heat energy needed to evaporate 200g of water?

$$Q = mL_v = \left(\frac{200}{1000}\right)(2.26 \times 10^6) = \mathbf{452000J}$$

CONSERVATION OF ENERGY

$$\boxed{\boldsymbol{HEAT\ LOST\ IN\ A = HEAT\ GAINED\ BY\ B}}$$

Example 1

Water of mass 260g is at 18°C. Its temperature is to be brought down 0°C by adding ice to the water. The following are some data to be used

Specific capacity of water = $4200 J/kg$°C

$$L_f\ of\ ice = 340000 J/kg$$

1. How much heat is released if the temperature of water decreases to 0°C?

Change in temp: use $mc\Delta T$

$$Q = \left(\frac{260}{1000}\right)(4200)(0 - 18) = -19656J$$
$$= \mathbf{19656J\ lost}$$

2. If the temperature of ice is 0°C, what mass of ice is needed to cool water to 0°C?

$$\boldsymbol{HEAT\ LOST\ IN\ A = HEAT\ GAINED\ BY\ B}$$
$$19656 = mL_f(melting)$$
$$19656 = m(340000)$$
$$\frac{19656}{340000} = m = \mathbf{0.06kg}$$

Example 2

A 250g of ice was left outside and after a few days, all ice had disappeared. Calculate the total amount of energy used to vaporize all ice.

$Specific\ heat\ of\ water = 4200 J/kg$°C

$L_v\ of\ water = 2.3 \times 10^6$J/kg

$L_F\ of\ ice = 340\,000 J/kg$

- $ice(0°C) \rightarrow water(0°C) \rightarrow water(100°C) \rightarrow vapour(100°C)$
- $ice \rightarrow water: mL_f$

$water(0°C) \rightarrow water(100°C): mc\Delta T$

$water(100°C) \rightarrow vapor(100°C): mL_v$

$\boldsymbol{Q_{total} = mL_f + mc\Delta T + mL_v}$

$= (0.25)(340000) + (0.25)(4200)(100) + (0.25)(2.3 \times 10^6)$

$= 85000 + 105000 + 575000$

$= \mathbf{765000J = 765KJ}$

Exercises

1. Ammonia is vaporized in order to freeze an ice rink. Raina uses heat from water to vaporize 1 g of ammonia. Assuming this heat is taken from water at 0°C, find the mass of water frozen for every gram of ammonia vaporized.

   $L_v of\ ammonia = 1.34\ x\ 10^6 J/kg$

   $L_F of\ ice = 3.34\ x\ 10^5 J/kg$

2. Sera placed 200 g of dry ice in a bucket and left it near the window. She returned after 5 days to find nothing was left in the bucket. Assuming that all ice had melted and evaporated over the 5 days, determine how much energy was used by the ice to completely evaporate.

   $Specific\ heat\ of\ water = 4200 J/kg$°C

   $L_v\ of\ water = 2.3 \times 10^6$J/kg

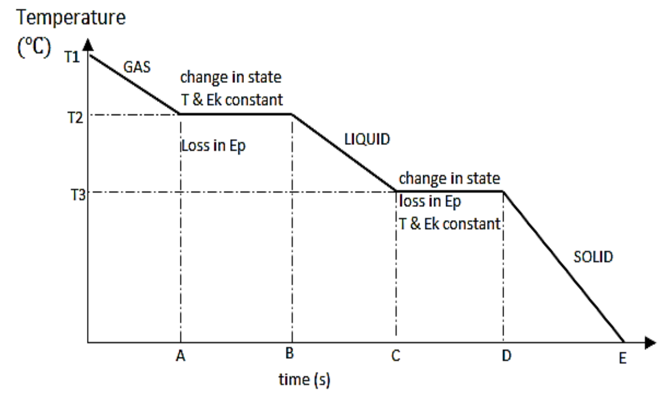
   $L_F\ of\ ice = 340\,000 J/kg$

3. A steel bearing ball with a mass of 0.012 kg requires 132 J of energy when heated from 12°C to 28°C. Calculate the specific heat capacity of the steel ball.

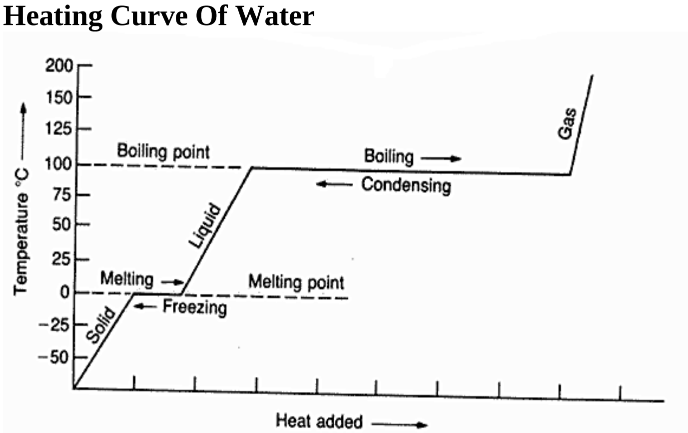
WEEK 5
MONDAY: 02/08/2021 - FRIDAY: 06/08/2021
Achievement indicator:

- Describe evidence of global warming, consequences of it and possible solution

Cooling curve of Naphthalene

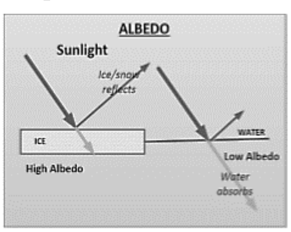


Heating Curve Of Water



ALBEDO

When sunlight reaches the Earth's surface, some of it is absorbed and some is reflected. The relative amount (ratio) of light that a surface reflects compared to the total sunlight that falls on it is called albedo. In other words, Albedo is the fraction of solar energy (shortwave radiation) reflected from the Earth back into space.



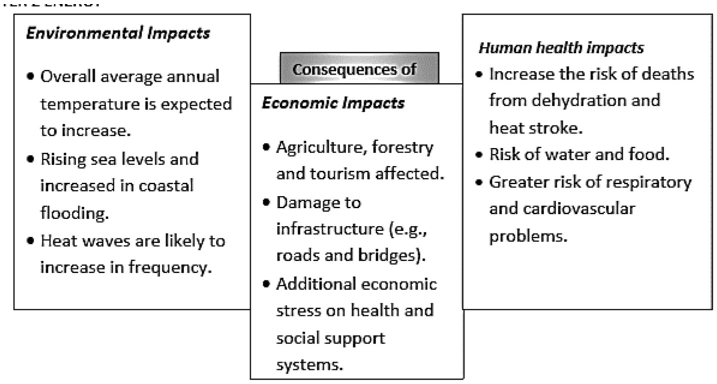
GREENHOUSE EFFECT

The greenhouse effect is the natural process by which the atmosphere traps some of the Sun's energy, warming the Earth enough to support life. Without the greenhouse effect, the earth would be much cooler than it is now and life would be difficult. However, too much greenhouse warming could raise global temperatures to a level that is significantly different than the current climate**.**

The original concept of the greenhouse effect dates back to 1824 with **Joseph Fourier**.

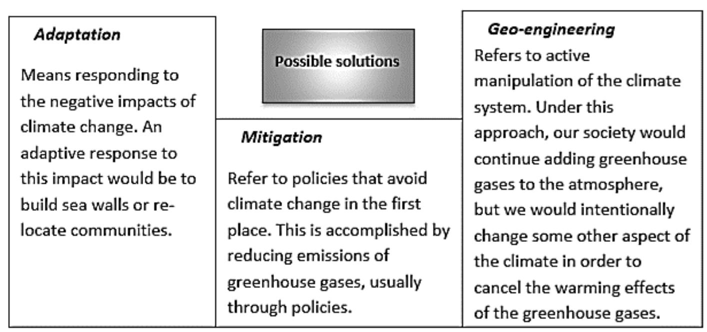
Consequences of greenhouse-effect

The release of GHGs and their increasing concentration in the atmosphere are already having an impact on the environment, human health and the economy. These impacts are expected to become more severe, unless concerted efforts to reduce emissions are undertaken



Possible solutions

There are various options available to us to address climate change. Our responses to climate change can be broadly split into three categories: adaptation, mitigation, and geo-engineering.



EXERCISES

1. Discuss the possible causes and consequence of Greenhouse effect

2. Define the term ALBEDO.

3. Describe evidences of global warming and what are the solutions to this?

WORKSHEET

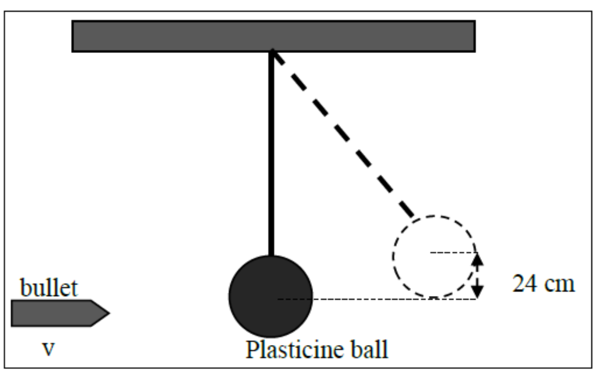
1. The type of energy involved to heat 1 kg of water at 10 ºC to 50 ºC is:

A. specific latent heat.
B. latent heat of fusion.
C. specific heat capacity.
D. latent heat of vaporization.

2. Which of the following is a greenhouse gas?

A. helium.
B. methane.
C. carbon monoxide.
D. carbon tetrachloride.

3. In an experiment to measure the speed of a bullet, the bullet was fired into a Plasticine ball of mass 0.38 kg, suspended from a rigid support by a light thread. The impact speed of the bullet is v, while its mass is $5.2 \times 10^{-3}\ kg$. The bullet embeds itself in the plasticine ball after impact, which causes it to rise to a height of 24 cm.

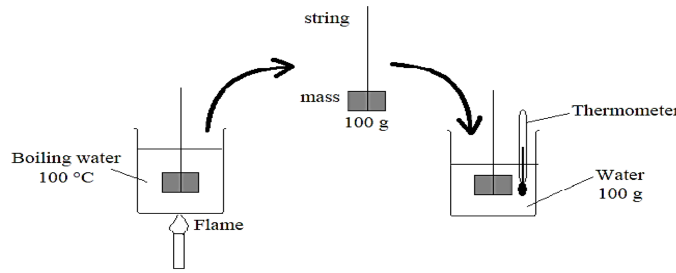


(i) Calculate the potential energy gained by the Plasticine ball.

(ii) Calculate the impact speed, v, of the bullet.

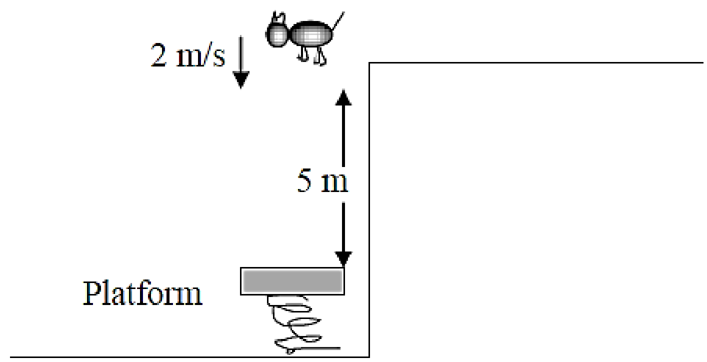
(iii) Identify the important law that was verified in this set-up.

4. In a Form 6 Physics experiment, a 100 g piece of metal is placed in boiling water at 100 °C for about 5 minutes. It is taken out and dropped into 100 g of water at 20 °C. The maximum final temperature of the mixture is 26.6 °C. The specific heat capacity of water is 4.2 J/g°C



Calculate the specific heat capacity of the metal.

5. A cat of mass 4 kg jumps off a cliff with an initial vertical velocity of 2 m/s onto a platform situated 5m below the cliff as shown below.



After touching the platform, the cat is bounced into the air to a vertical height of 4 m.

(i) Calculate the kinetic energy of the cat as it hits the platform
.

(ii) The spring attached to the platform is compressed as the cat hits the platform. Determine the compression of the spring if its spring constant is 200 N/m.

(iii) How much energy is lost as the cat bounces off the platform?