SUVA SANGAM COLLEGE
YEAR 11
PHYSICS

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

STRAND	**P11.2** ENERGY
SUB-STRAND	**P11.2.1** WORK,POWER AND ENERGY
CONTENT LEARNING OUTCOME	**P11.2.1.1** Use basic concepts of work, energy and power in applications of the law of conservation of energy to real life examples.
REFERENCE FROM TEXT	**Pg 75 - 86**

Achievement Indicators

- Calculate the work done in (Joules) by a constant force using the formula Work = Force x Distance.
- Recognize examples of an applied force doing no work

STRAND 2
ENERGY

- We use energy every day
- Energy stored in plants is eaten by animals, giving them energy. And predator animals eat their prey, which gives the predator animal energy.
- Everything we do is associated to energy in one form or another.

WORK DONE BY A CONSTANT FORCE

- Work is defined as a force applied through a distance. Work done on an object by a constant force is the product of the object's displacement and the force acting parallel to the displacement.
  $\boxed{W = F \times d}$ Where F = force (N)
  and d = distance (m)
- The SI unit for work is the **joule** (J) or **Newton meter** (Nm)

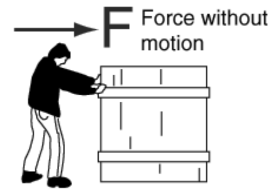
Example 1
If a girl pushes a box with a 5.0 N force, and the box travels 2.0 m in the direction of her push, the amount of work done will be:

$\boldsymbol{W = F \times d}$
$\boldsymbol{W = 5.0 \times 2.0}$
$\boldsymbol{W = 10J}$

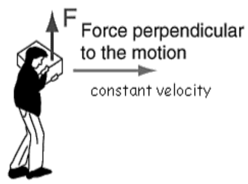
Example 2
A 10 kg object experiences a horizontal force which causes it to accelerate at 5 m/s^2 , moving it a distance of 20 m, horizontally. How much work is done by the force?

$\boldsymbol{W = F \times d}$
$\boldsymbol{W = (10 \times 5) \times 20}$ (note F = ma)
$\boldsymbol{W = 1000J}$

WHEN A FORCE DOES NO WORK
A force with no motion or a force perpendicular to the direction of motion does no work.



In the diagram on the left, no matter how hard or how long you have pushed, if the crate does not move, then you have done no work on the crate.



In the diagram on the left, the force exerted by the person is an upward force equal to the weight of the box, and that force is perpendicular to the motion. When there is no motion in the direction of the force, then no work is done by that force.

Exercises

1. The work done in moving a block across a rough surface and the heat energy gained by the block can both be measured in

A. Watts B. Newtons
C. degrees D. Joules

2. Which of the following has the greatest gravitational energy with respect to the floor?
   A. 6 kg mass placed 5 m above the floor.
   B. 10 kg mass placed 2 m above the floor.
   C. 2 kg mass placed 10 m above the floor.
   D. 1000 kg mass resting on the floor

3. A man lifts a 10 kg parcel to a height of 80cm above the ground at a constant speed of 1 m/s.

(a) The work he does on the parcel is
A. 800 J B. 80 J
C. 8000 J D. 0 J

(b) The man now holds the parcel at the same height above the ground. The work he does now on the parcel is
A. 800 J B 80 J
C. 8000 J D. 0 J

WEEK 2

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

Achievement Indicators

- Define energy and distinguish it from the concept of work.
- Demonstrate understanding of the concept of power, defining it in words and in symbols.

Energy can be defined as the capacity for doing work. The simplest case of mechanical work is when an object is standing still and we force it to move. The energy of a moving object is called kinetic energy.

Note:

1. Energy is the ability to produce or create work. Work, on the other hand, is the ability to provide force and a change in distance to an object.
2. There are many types of energy such as solar energy, etc., but there is only one type of work.
3. Both work and energy are scalar units.
4. Both work and energy are measured in joules.

POWER

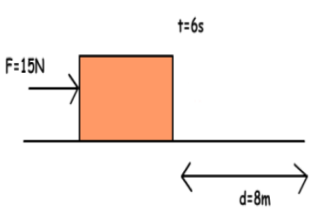
- Power is the rate of work done in a unit of time.

$$\boxed{\text{Power} = \frac{\text{Workdone}}{\text{Time taken}}}$$

- The unit of power is, J/s, however, we generally use watts (W).
  1 J/s = 1 W
- Note: Amount of power does not show the amount of work done. It just gives the time that work requires.

Example 1.

Find the power of the man who pushes a box 8 m with a force of 15 N in 6 seconds.



$$P = \frac{W}{t}$$

$$P = \frac{F \times d}{t}$$

$$P = \frac{15 \times 8}{6}$$

$$\boldsymbol{P = 20W}$$

Example 2

Find the power a student uses if he was able to carry a 3kg box up a distance of 5m in 10s

$$P = \frac{W}{t}$$

$$P = \frac{F \times d}{t}$$

$$P = \frac{(3 \times 10) \times 5}{10} \quad \text{(note: F= mg)}$$

$$\boldsymbol{P = 15W}$$

Example 3

Two machines (e.g., elevators) might do identical jobs (e.g., lift 10 passengers three floors) and yet the machines might have different power outputs. Explain how this can be so.

Power is the rate at which work is done. The two machines are doing the same amount of work, yet doing the work at different rates. One machine might do the job very quickly and the other very slowly. The machine that does the work in the least amount of time (quickly) is most powerful

EXERCISES

1. Bart runs up a 2.91-meter high flight of stairs at a constant speed in 2.15 seconds. If Bart's mass is 65.9 kg, determine the work which he did and his power rating
2. On a recent adventure trip, Anita Break went rock-climbing. Anita was able to steadily lift her 80.0-kg body 20.0 meters in 100 seconds. Determine Anita 's power rating during this portion of the climb.
3. An elevator motor lifts 715 kg of mass to the height of the fourth floor of an office building (11.0 meters above ground level) at a constant speed in 9.35 seconds. Determine the power rating of the motor.

WEEK 3
MONDAY: 19/07/2021 - FRIDAY: 23/07/2021
Achievement Indicators

• Name the major forms of energy, and show an understanding of its conservation in terms of the energy transformations occurring in a given situation.

• Recognize that the work done results in an equal energy change and to apply this in problems.

FORMS OF ENERGY
There are many forms of energy: like solar, wind, wave and thermal to name a few, but we will look at 5 only.

1. Mechanical energy:
- The sum of potential energy and kinetic energy present in the components of a mechanical system.
- It is the energy associated with the motion or position of an object
- There are two types; energy of motion (kinetic energy) or stored energy of position (potential energy).
- Motion energy: This is the energy something has because it is moving
- Stored mechanical energy: This is energy something has stored in it because of its height above the ground or because it is stretched or bent or squeezed
- Stored mechanical energy is also called potential energy.

2. Nuclear energy
- The reactor uses Uranium rods as fuel, and the heat is generated by nuclear fission: neutrons smash into the nucleus of the uranium atoms, which split roughly in half and release energy in the form of heat.
- Carbon dioxide gas or water is pumped through the reactor to take the heat away, this then heats water to make steam.
- The steam drives turbines which drive generators and produces electricity.

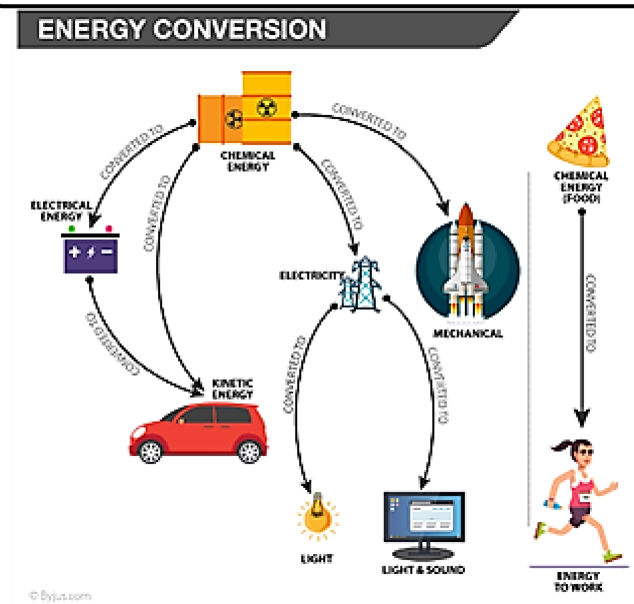
3. *Radiant energy*
- is the energy of electromagnetic waves.
- sometimes used to refer to the electromagnetic waves themselves, rather than their energy (a property of the waves), Because electromagnetic (EM) radiation can be considered to be a stream of photons, radiant energy can be viewed as the energy carried by these photons.
- The sun provides radiant energy.

4. *Electrical energy*
- Energy stored in a charged particle within an electric field.
- Electric fields are areas surrounding a charged particle that exert a force on another charged particle within the field.

- Electrical energy is a type of potential energy, or energy stored in an object due to the position of the object.
- In the case of electrical energy, the object is the charged particle, and the position is within the electric field.
- Another way of looking at electrical energy is electrical potential, which is measured in volts. Electrical energy is used to move charges through wires to create current, or electricity.

5. *Chemical energy*
- Chemical energy is energy that has been stored in chemical form, such as in fuels or sugars or as energy stored in car batteries. Gasoline is a chemical that combines with oxygen and a little heat to release the great amount of thermal energy stored in the chemical structure of the gasoline. Other such chemicals include sucrose, methane, ethanol, and methanol.

CONSERVATION OF ENERGY
- Energy is always conserved, it is neither created nor destroyed



EXERCISES
1. Define Energy
2. List the 5 forms of energy discussed in this lesson
3. Explain the difference between potential energy and kinetic energy
4. State the energy conversion when a car moves

WEEK 4
MONDAY: 26/07/2021 - FRIDAY: 30/07/2021
Achievement indicator:

- Show understanding of the concepts of gravitational potential energy and kinetic energy, using associated formulae in simple applications of these.

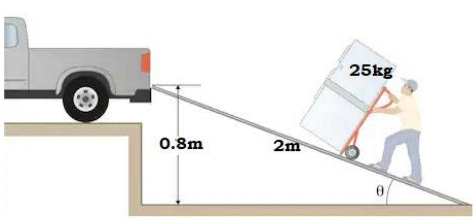
POTENTIAL AND KINETIC ENERGY

Potential Energy

- Gravitational potential energy is the energy stored in an object as the result of its vertical position or height. The energy is stored as the result of the gravitational attraction of the Earth for the object.
- The gravitational potential energy dependent on two variables. They are the mass of the object and the height to which it is raised.
- **PE_{grav} = mass x pull of gravity (g) x height**
  PE = mgh
- (gravitational field g = 10 N/kg on the Earth).

Examples

1. What is the potential energy of a 6 kg mass 4 m above the ground?
   $PE = mgh$
   $PE = (6)(10)(4)$
   $\boldsymbol{PE = 240J}$
2. A man slides a 25 kg box up a ramp onto the back of a lorry. If the ramp is 2 m long and the back of the lorry is 0.8 m above the ground how much potential energy does the box gain? All that matters is the VERTICAL height moved and not the length of the ramp.



$PE = mgh$
$PE = (25)(10)(0.8)$
$\boldsymbol{PE = 200J}$

Kinetic Energy

Kinetic energy is energy of motion or because it is moving. The kinetic energy of a mass m is given by
$\boldsymbol{E_k = \frac{1}{2}mv^2}$

where Ek is the kinetic energy
m = mass of object (kg)
v = speed of object (m/s)

Examples

1. What is the kinetic energy of a 500 kg horse running at 15 m/s?
   $KE = \frac{1}{2}mv^2$
   $KE = \frac{1}{2}(500)(15)^2$
   $\boldsymbol{KE = 56250J}$

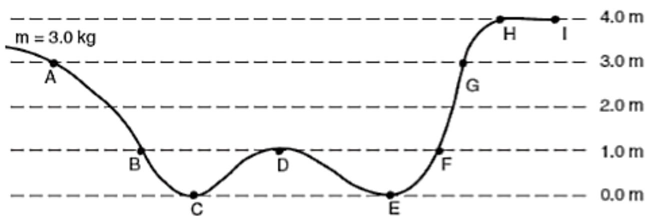
2. What is the kinetic energy of a one milligram raindrop falling at 0.5 mm/s.
   $KE = \frac{1}{2}mv^2$
   $KE = \frac{1}{2}(1 \times 10^{-6})(0.0005)^2$ ***(Convert mass to kg and velocity to m/s)***
   $\boldsymbol{KE = 1.25 \times 10^{-13}J}$

Exercises

1. A ball has a mass of 2 kg. It is dropped from a cliff and strikes the ground below at 10 m/s.

i. What is the kinetic energy as it is about to strike the ground?
ii. What was its potential energy before it was dropped?
iii. Determine the height from which it was dropped

2. A 3.0 kg object is placed on a frictionless track at point A and released from rest.



i. Calculate the gravitational potential energy of the object at point A.
ii. Calculate the kinetic energy of the object at point B.
iii. Which letter represents the farthest point on the track that the object will reach?

WEEK 5

MONDAY: 02/08/2021 - FRIDAY: 06/08/2021

Achievement indicator:

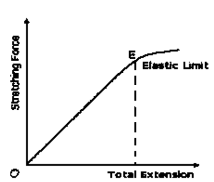
- Recognize that springs and other elastic materials can store potential energy convertible to kinetic energy form.

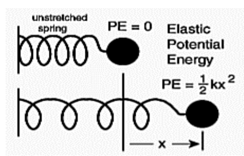
HOOKE'S LAW

Hooke's law states that the force applied is proportional to the extension of spring provided the elastic limit is not exceeded:

F = -kx

where F = Force applied on spring (N)
x = Extension on the spring (m)
k = spring constant (N/m)





Example 1

A spring is stretched by 50 cm and has force constant of 2 N/m. Calculate the Force applied?

List information

$x = 50cm = 0.5m \quad k = 2N/m \quad F = ??$

$F = -kx$

$F = -(2)(0.5) = \mathbf{-1N}$

Example 2

A force of 100 N is stretching a spring by 0.2 m. Calculate the force constant?

List information

$x = 0.2m \quad k = ?? \quad F = 100N$

$F = -kx$

$100 = -(k)(0.2)$

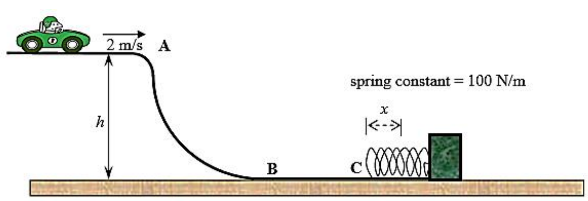
$100 = -0.2k$

$\frac{100}{-0.2} = \frac{-0.2k}{-0.2}$

$\mathbf{-500N/m = k}$

Example 3

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



Identify the knowns

$m = 0.5kg$ *v at A = 2m/s*   *v at B = 10m/s*   *k = 100N/m*

(i) Calculate the total energy at B

$Energy\ at\ B = Kinetic\ energy$ (KE because the car is in motion)

$energy\ at\ B = \frac{1}{2}mv^2$

$Energy\ at\ B = \frac{1}{2}(0.5)(10)^2$ (plug in the knowns with respect to B)

$\boldsymbol{Energy\ at\ B = 25J}$

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

Energy at A = potential energy + kinetic energy*(at A the car is at a height and is moving also thus PE+KE)*

Energy at A = mgh + ½ mv²

Energy at A = (0.5)(10)(h) + ½ (0.5)(2)²

(plug in the knowns and solve)

25 = 5h + 1

25-1 = 5h +1 – 1

24 = 5h

$\frac{24}{5} = \frac{5h}{5}$ ***=4.8m = h***

(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.

Energy at B = energy in the spring *(law of conservation of energy)*

25J = ½ kx²

25 = ½ (100) (x)²

25= 50x²

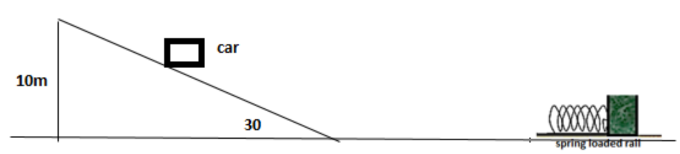
$\frac{25}{50} = \frac{50x^2}{50}$

0.5 = x²

$\sqrt{0.5} = x$ ***0.71m = x***

EXERCISES

1. A 1300kg 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 $1.0 \times 10^6 N/m$



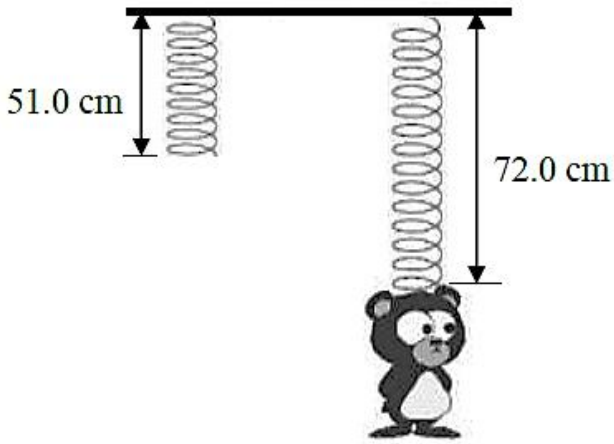
Neglecting any friction effects

(i) Calculate the speed of the car just before it collides with the rail
(ii) Determine the maximum distance that the spring is compressed
(iii) Calculate the acceleration of the car along the slope

WORKSHEET

1. State **Hooke’s Law**.

2. When a toy teddy bear of 400 g is attached at the end of a 51.0 cm long vertically hanging spring, it stretches to 72.0 cm

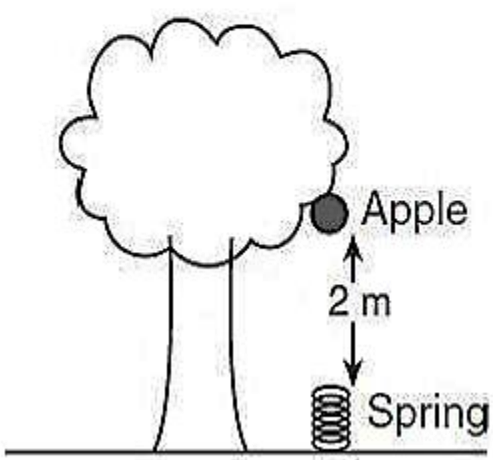


Calculate the:

(i) Spring constant.

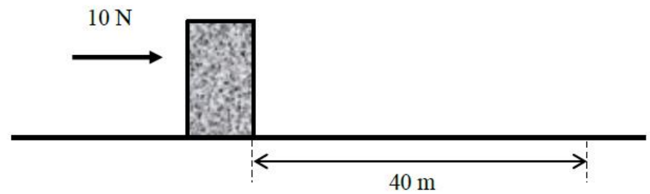
(ii) Energy stored in the spring.

3. The diagram below shows a 0.1 kg apple attached to a branch of tree 2 meters above a spring on the ground below.



The apple falls and hits the spring, compressing it 0.1 m from its rest position.
Suppose all of the gravitational potential energy of the apple on the tree is transferred to the spring when it is compressed. Calculate the spring constant.

4. A block of 5 kg is pushed with a force of 10N for 40 meters in 5 seconds.

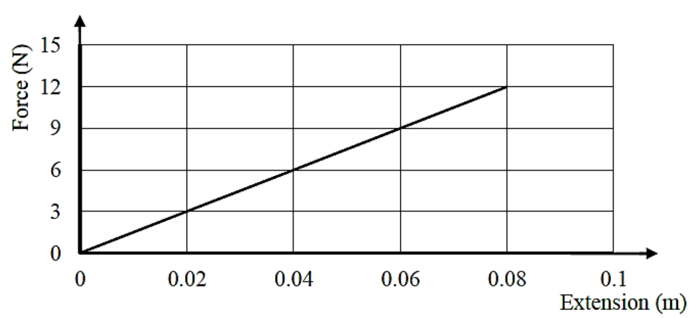


(i) Calculate the work done if a force of 10 N is maintained over the entire 40 m.

(ii) Calculate the power developed by pushing the block.

(iii) Determine the work done on the block if it moves over a distance of 40 meters when a force 20 N is directed perpendicular to the block’s displacement.

5. A group of physics students performed an experiment in which the weight attached to a suspended spring was varied and the resulting total length of the spring was measured. The graph below shows the force-extension graph obtained by the students



(i) Calculate the spring constant.

(ii) Determine the total energy stored in the spring when it extends to 0.08 m.