MINISTRY OF EDUCATION

SECONDARY ENGAGEMENT PROGRAMME

GRADE 10

PHYSICS

WEEK 13 **LESSON 2**

TOPIC: Work, Energy and Power

SUB-TOPIC: Efficiency

OBJECTIVE: At the end of this lesson, students will be able to:

h) Explain the concept of efficiency and calculate the efficiency of some systems

i) Define mechanical advantage and velocity ratios

CONTENT

Efficiency

Efficiency is a measure of how much work or energy is conserved in a process. In many processes, work or energy is lost, for example as waste heat or vibration. The efficiency is the energy output, divided by the energy input, and expressed as a percentage. A perfect process would have an efficiency of 100%.

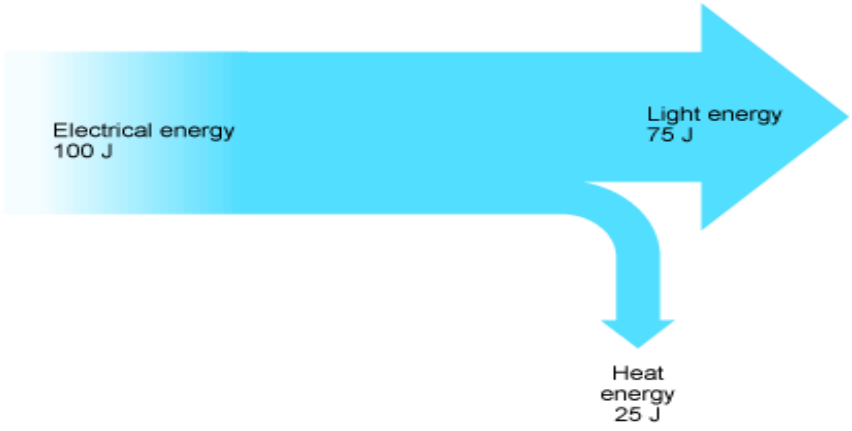
It is calculated using the following formulae:

$$efficiency = \frac{useful\ work\ or\ energy\ output}{work\ done\ or\ energy\ input} \times 100\%$$

or

$$efficiency = \frac{useful\ power\ output}{power\ input} \times 100\%$$

Thermal energy produced due to friction is the main reason for systems having low efficiency.



MINISTRY OF EDUCATION

SECONDARY ENGAGEMENT PROGRAMME

GRADE 10

PHYSICS

Question 1

A warehouse fork-lift takes 4s to lift a crate of mass 1000kg through 5m working at a rate of 20kW. Five percent of the wasted energy in the forklift is used to lift moving parts of the fork-lift and the rest is lost as electrical heating and frictional heating. Calculate:

i) The efficiency of the fork-lift at this load

ii) The value of the total energy wasted

iii) The amount of heat developed in lifting the crate

Solution

i) Efficiency = $\frac{useful\ energy\ converted\ to\ work\ in\ lifting\ the\ crate}{total\ electrical\ energy\ supplied\ to\ the\ fork-lift} \times 100\%$

Remember: energy = power* x *time

Work done = force* x *displacement

$= \frac{5m \times 10000N}{20000W \times 4s} \times 100\%$

$= \frac{50000J}{80000J} \times 100\%$

$= 62.5\%$

ii) If 62.5% of the energy supplied to the fork-lift is usefully used (to lift the load) then 37.5% is wasted.

Wasted energy = 37.5% of 80 000J

= 30 000J

iii) If 5% of this wasted energy is used to lift certain moving parts, then 95% of it is wasted as heat.

Amount of energy lost as heat = 95% of 30 000J

$= (\frac{95}{100})$ x 30 000J

= 28 500J

MINISTRY OF EDUCATION

SECONDARY ENGAGEMENT PROGRAMME

GRADE 10

PHYSICS

Mechanical Advantage and Velocity Ratio

Some machines are designed so that a small effort force can overcome a larger force. These machines are called force multipliers. The crowbar is an example of a force multiplier.

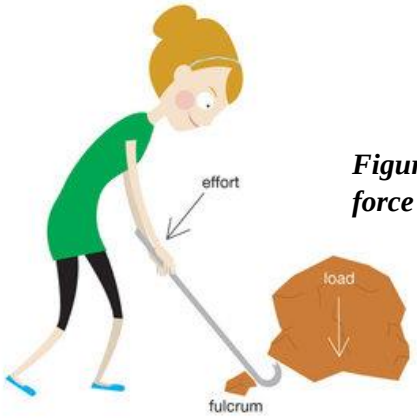


Figure 1: crowbar acting as a force multiplier to lift heavy load

The mechanical advantage of a machine is a measure of how great the load force overcome is compared with the effort force.

$$mechanical\ advantage\ (MA) = \frac{load}{effort}$$

Some machines are designed so that a small movement of the effort causes a larger movement of the load. These machines are called distance multipliers. The human forearm is a distance multiplier.

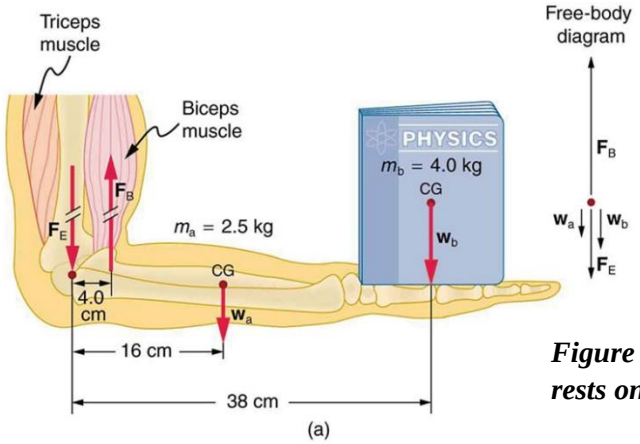


Figure 2: forces acting as object rests on hand

The velocity ratio of a machine is a measure of how far or how fast the effort moves compared with the load.

$$velocity\ ratio\ (VR) = \frac{distance\ moved\ by\ effort}{distance\ moved\ by\ load}$$

Question 2

A construction worker uses a lever with a velocity ratio of 6 to raise a stone block 15cm so that it can be slid onto a wooden pallet. The block has a weight of 2800N. If the construction worker pushes down on the lever with an effort of 500N, calculate:

a) The work done by the construction worker
b) The useful work done by the lever
c) The mechanical advantage of the lever
d) The efficiency of the lever

Solution

a) a VR of 6 means the effort moves 6 times the load distance so
   Distance effort moves = 6 x 15cm = 90cm = 0.9m
   Work done by worker = force x displacement = 500N x 0.9m = 450J
b) Useful work done = force to overcome load x distance load is raised
   Useful work done = 2800N x 0.15m = 420J
c) MA = load ÷ effort = 2800N ÷ 500N = 5.6
d) Efficiency = (useful work output ÷ work input) x 100%
   = (420J/450J) x 100%
   = 93%

REFERENCES:

- DeFreitas, P. (2015). *Concise Revision Course CSEC Physics.* London: Collins.
- Duncan, T. (2013). *Physics for CSEC examination* (5th ed.). London: Hodder Education.
- Farley, A., & Trotz, C. (2014). *Physics for CSEC Examinations* (3rd ed.). (M. Taylor, Ed.) London: Macmillan.