Province of the
EASTERN CAPE
EDUCATION

DIRECTORATE SENIOR CURRICULUM MANAGEMENT (SEN-FET)

HOME SCHOOLING SELF-STUDY WORKSHEET

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<tr><td>SUBJECT</td><td>AUTOMOTIVE</td><td>GRADE</td><td>12</td><td>DATE</td><td>30/03/2020</td></tr>
<tr><td>TOPIC</td><td>FORCES</td><td>TERM 1 REVISION</td><td>(Please tick)</td><td>TERM 2 CONTENT</td><td>(√)</td></tr>
<tr><td>TIME ALLOCATION</td><td>2 hrs. 30 min</td><td colspan="4" rowspan="2"><u>TIPS TO KEEP HEALTHY</u>

1. WASH YOUR HANDS thoroughly with soap and water for at least 20 seconds. Alternatively, use hand sanitizer with an alcohol content of at least 60%.
2. PRACTICE SOCIAL DISTANCING – keep a distance of 1m away from other people.
3. PRACTISE GOOD RESPIRATORY HYGIENE: cough or sneeze into your elbow or tissue and dispose of the tissue immediately after use.
4. TRY NOT TO TOUCH YOUR FACE. The virus can be transferred from your hands to your nose,</td></tr>
<tr><td>INSTRUCTIONS</td><td>Find material on Automotive Forces provided below and work through given examples and activities.
NB Pay attention to definitions and formulae as provided in order for you to master the content on Automotive forces.</td></tr>
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		mouth and eyes. It can then enter your body and make you sick. 5. **STAY AT HOME.**

DEFINITIONS OF TERMS:

Force: Force is a push or a pull effect.

Work:

Work is the moving of an object against an opposing force. The object can be moved by a push pull or lifting movement. Distance times force will equal work.

Work will be force (n) x displacement (m)

Power:

Work can be done slowly or rapidly. The rate at which work is done is measured in terms of power. Power is the rate or speed at which work is done. Measured in Kilowatt / N.m/s

Torque:

Torque is a twisting or turning effort. Example when opening a screw cap bottle you apply torque to open it or the drive shafts of a vehicle apply torque to the wheels to turn them.
Torque = force x distance.

Mean Effective Pressure [M.E.P]

The mean effective pressure is a theoretical parameter used to measure the performance of an internal combustion engine. It can also be regarded as an average pressure in the cylinder for a complete engine cycle. The mean effective pressure is obtained by multiplying the mean height (mm) by the spring scale ($N/m^2.mm$)

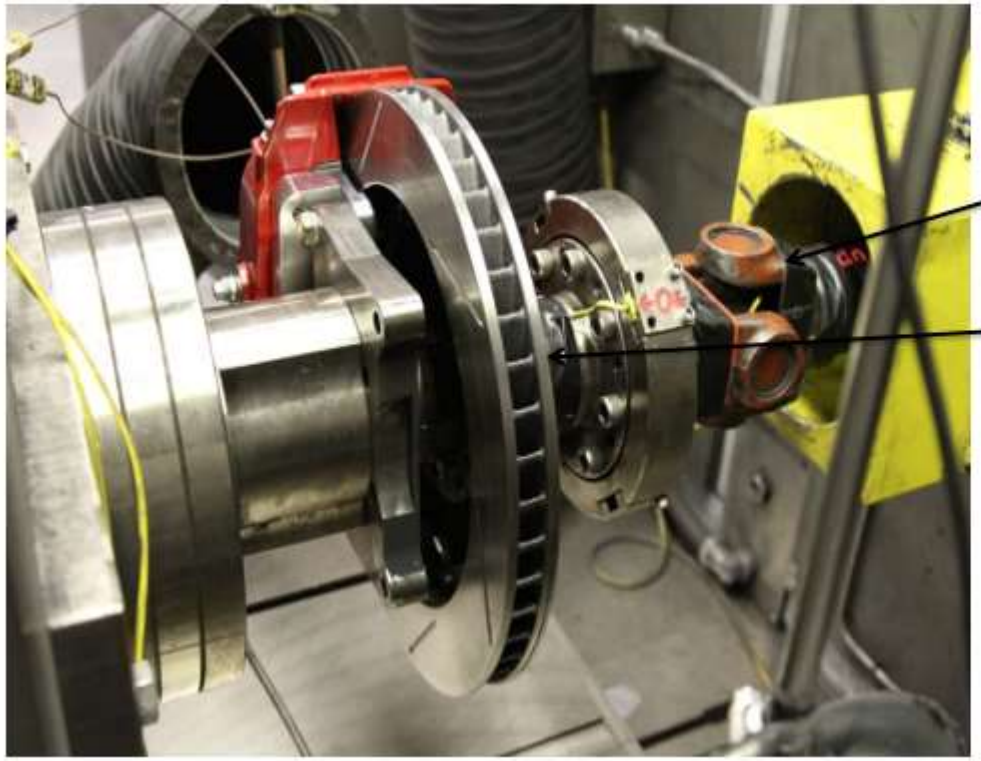
ACTIVITY 1

A hoist steadily lifts an engine 2 meters up in 15 seconds. Given 500 kg as the mass of the engine. 9.8 m/s^2 as the gravitational force.

First determine the work done, which requires the force necessary to lift the car against gravity.

Calculate the power used to lift the engine.

PRONY BRAKE EXAMPLE

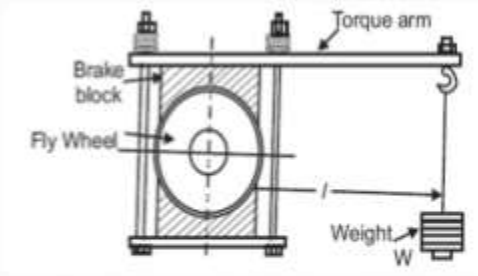


DYNOMETER

Eddy current dynamometers use a magnetic field to provide counter restraining torque that increases with shaft speed.

PRONY BRAKE DYNAMOMETER

- It works on the principle of converting power into heat by dry friction.
- In this method of measuring horsepower is to attempt to stop the engine by means of a brake on the flywheel and measure the weight which an arm attached to the brake will support, as it tries to rotate with the flywheel.



$$B.P. = \frac{\text{Work done per min.}}{60} = \frac{T \times 2\pi N}{60} = \frac{W.L \times 2\pi\ N}{60} \text{ watts}$$

EXAMPLE

An engine develops a torque of 315 N.m at 3012 revolutions per minute. Calculate the brake power in kW

BP = 2π N T

$$= \frac{2\ \pi\ 3012 \times 315}{60}$$

= 99,356 kW

INDICATED POWER

- Indicated power is the theoretical power that an engine develops without taking mechanical or other losses into consideration
- Formula used = PLANn

P = Mean effective pressure measured in N/m^2, 1 N/m^2 = 1 Pa

Mean effective pressure is derived from a planimeter

The mean effective pressure can be regarded as an average pressure in the cylinder for a complete engine cycle. By definition, mean effective pressure is the ratio between the work and engine displacement:

L = Stroke length in metres (m)

A = Area of piston crown measured in metres (m^2)

N = Power strokes per second r/s

n = Number of cylinders

INDICATED POWER CALCULATION

FORMULA - IP = PLANn

DATA GIVEN:

- Mean effective pressure = 900 kPa = 900000 pa
- Length of stroke 86 mm $\div 1000 = ,086$
- Cylinder diameter 84 mm $\div 1000 = ,084$
- Area of piston crown? = $\frac{\pi D^2}{4} = \frac{\pi,084^2}{4}$

= 0,00554 m²

- Revolutions per minute = 4000 = 33,3 r/s
- Number of cylinders = 2

IP = 900000 x ,086 x ,00554 x 33,3 x 2

= 28557,8 watt $\div 1000$

= 28,6 kW

ACTIVITY 2

Given that a four stroke engine has a mean effective pressure on piston = 750 kPa
Length of stroke = 65 mm
Bore (cylinder diameter) = 70 mm
Revolutions per minute = 3500
Number of cylinders = 4
Calculate the indicated power

I.P = PLANn

BRAKE POWER

Brake power is the actual power developed by an engine and is measured at the flywheel or driving wheels

FORMULA - BP = 2πNT or F x 2x π x R x N

N = Power strokes per second (revolutions per second)

T = Torque Newton metre(Nm.)

R = Length of brake arm Metre (m)

F = Reading of the scale kg convert to Newton x 9.8

DATA GIVEN:

Revolutions = 2000 ÷ 60 = 33,3 r/s

Scale reading = 25 kg x 9,8 = 245 N

Brake arm length = 420 ÷ $1000 =$ $,420\,m$

Torque = force x radius = 245 x ,420 = 102,9 Nm.

BP = 2 x π x 33,3 x 102,9

= 21529,77 watt

= 21,5 kW

MECHANICAL EFFICIENCY

Mechanical efficiency is defined as the ratio of indicated power to brake power (measured at the flywheel) or obtained from a dynamometer. This is expressed as a percentage (%).

FORMULA – ME = $\frac{BP\ X\ 100}{IP}$

Data given:

BP = 80 kW

IP = 90 kW

ME = $\frac{80\ x\ 100}{90}$

= 88,8%

ACTIVITY 3

The brake power of an engine is 60 kW and the indicated power is 70 kW.

Calculate the mechanical efficiency of the engine.

ACTIVITY 4

The following data was recorded during a test carried out on a four-stroke, four-cylinder petrol engine:

Brake wheel diameter:	820 mm
Rope diameter:	20 mm
Brake dead weight:	765 N
Spring balance reading:	15 N
Speed during test:	1 200 r/min
Mean effective pressure:	800 kPa
Bore diameter:	110 mm
Stroke:	150 mm

Determine, by means of calculations:

a) Torque

b) Indicated power

c) Brake power in kW

d) Mechanical efficiency

COMPRESSION RATIO

When dealing with compression ratio, a learner must understand the following terminology:

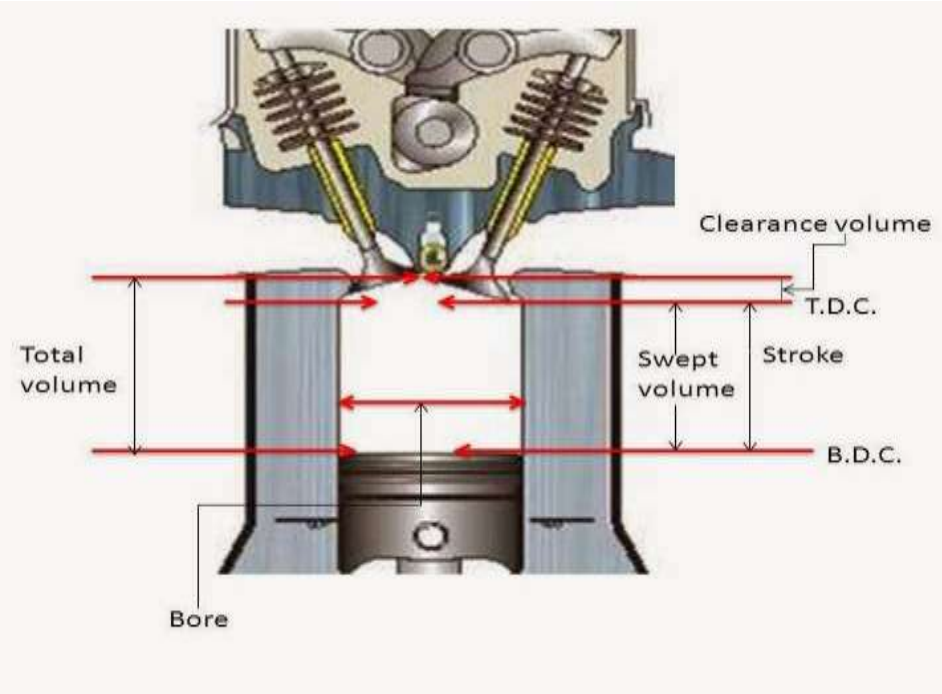
Top Dead Centre (TDC) – the furthest point reached by the piston top during its upward movement.

Bottom Dead Centre (BDC) – the lowest point reached by the piston top on its downward movement. See the drawing below.

Swept Volume (SV) – the volume of the engine cylinder between **BDC** and **TDC.**

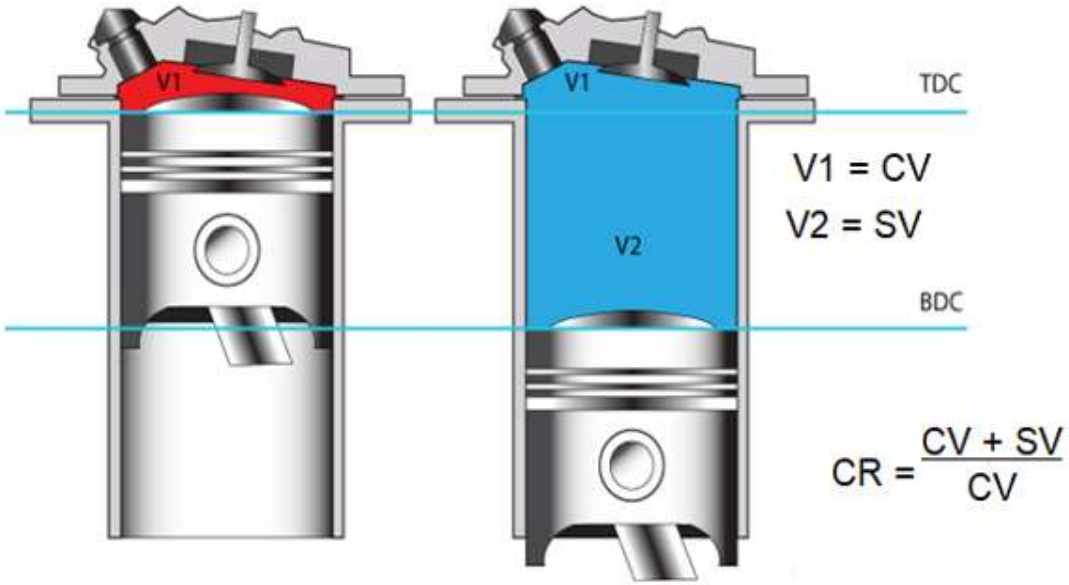
Clearance Volume (CV) – the volume above the piston when it is at **TDC**.

LABELLED SECTION THROUGH AN ENGINE CYLINDER



Definition:

Compression ratio is the ratio of the clearance volume above the cylinder at the end of the compression stroke to the total volume of the cylinder. Example below.



In other words, compression ratio is a comparison of the total volume of an engine cylinder (**swept volume** + **clearance volume)** when the piston is at BDC, to the volume of the cylinder when the piston is at TDC, **clearance volume**. Refer to the diagram above.

EXAMPLE OF COMPRESSION RATIO CALCULATION

FORMULA:

CR = $\frac{CV+SV}{CV}$

Data given:

Calculate the compression ratio of an engine with clearance volume of 50 cm³. The stroke length is 80 mm and the bore size is 90 mm.

SV = $\frac{\pi D^2}{4} \times L$

SV = $\frac{\pi 9^2}{4} \times 8$

SV = 508,9 cm²

CR = $\frac{50+508,9}{50}$

CR = 11:1

ACTIVITY 5

Calculate the compression ratio of an engine with a bore of 80mm and stroke length of 90 mm. The combustion chamber volume is 50 cm^3.

ACTIVITY 6

The bore of an engine is 65 mm and the stroke length is 85 mm. The compression ratio is 8.5:1

Calculate,

a) The clearance volume in cm^3
b) The swept volume in cm^3

ACTIVITY 7

The bore and stroke of an engine is 80 mm and 90 mm respectively. The compression ratio is 9,5: 1. Determine, by means of calculations:

a) The swept volume in cm^3
b) The original clearance volume in cm^3
c) The compression ratio is increased to 10: 1. What will the new diameter of the bore be if the clearance volume remains unchanged? Answer must be in mm.