TVET CERTIFICATE III IN AUTOMOBILE TECHNOLOGY

FUNDAMENTAL AUTOMOTIVE SCIENCE

AUTAS301 APPLY FUNDAMENTAL AUTOMOTIVE SCIENCE

Competence

REQF LEVEL: 3

Learning hours: 30

Credits: 3

Sector: Transport and Logistic

Sub-sector: Automotive Technology

Module Note Issue date: November, 2020

Purpose statement

This general module describes the performance outcomes, skills and knowledge required to apply fundamental automotive science for an automotive manual drive train and brake systems. In order to perform many of particular competences successfully, a mechanic must apply principles of fundamental automotive science.

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Total Number of Pages: 28

Learning Unit 1 – Identify Kinematic constraints

LO 1.1 – Apply kinematic coupling

Introduction

This module covering general automotive calculation which can help learners to have general ideas in engine system, transmission system, brake system

- **Content/Topic 1 Identify definitions of kinematic coupling**

SOME DEFINITIONS:

Mechanics is that branch of physics, which deals with the behavior of the body when the body is at rest or in motion. Mechanics may be divided into **Statics** and **Dynamics**. The branch of physics, which deals with the study of the body when the body is at rest, is known as **Statics** while the branch of physics which deals with the body when the body is in motion, is known as **Dynamics**. Dynamics is further divided into **Kinematics** and **Kinetics**. The study of the body in motion, when the force which cause the motion are not considered, is called **Kinematics** and if the force are also considered for the body in motion, that branch of physics is called **Kinetics**.

Statics deals with equilibrium of bodies at rest, whereas Dynamics deals with the motion of bodies and the forces that cause them.

- **Content/Topic 2 Application of automotive technology**

1. **Plane motion**

A body has plane motion, if all its points move in planes, which are parallel to some reference plane. A body with plane motion will have only three degrees of freedom. I.e., linear along two axes parallel to the reference plane and rotational/angular about the axis perpendicular to the reference plane. (eg. linear along X and Z and rotational about Y.)The reference plane is called plane of motion. Plane motion can be of three types:

1) Translation

2) Rotation and

3) Combination of translation and rotation

TRANSLATION:

A body has translation if it moves so that all straight lines in the body move to parallel positions. Rectilinear translation is a motion where all points of the body move in straight-line paths. Eg. The slider in slider crank mechanism has rectilinear translation. (Link 4 in fig.1.1)

R. Gscheidle, S. (2006). *Mordern automotive Technology.* stuttgart: EUROPA REFERENCES BOOKS.

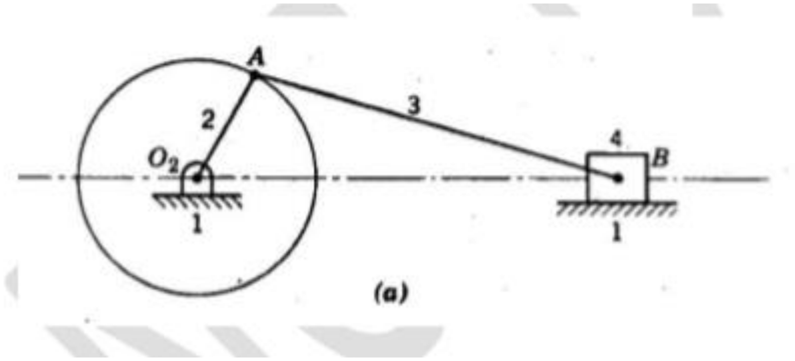


Figure 1: reciprocating piston

Translation, in which points in a body move along curved paths, is called curvilinear translation. The tie rod connecting the wheels of a steam locomotive has curvilinear translation. (link 3 in fig.1.2)

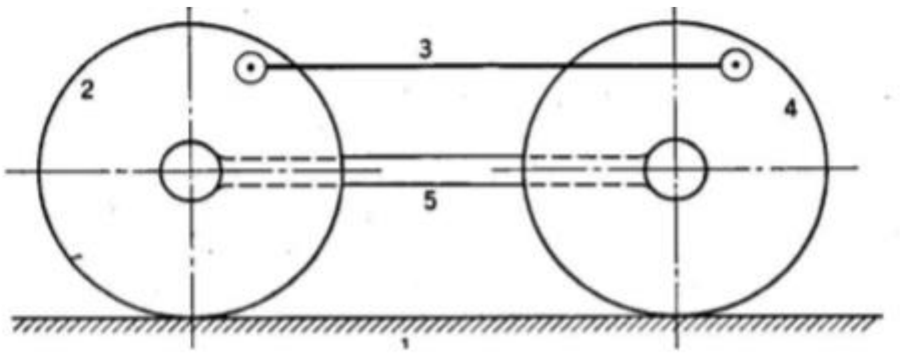


Figure 2: wheels

Rotation: In rotation, all points in a body remain at fixed distances from a line which is perpendicular to the plane of rotation. This line is the axis of rotation and points in the body describe circular paths about it. (Eg. link 2 in Fig.1.1 and links 2 & 4 in Fig.1.2)

Translation and rotation: It is the combination of both translation and rotation which is exhibited by many machine parts. (Eg. link 3 in Fig.1.1)

LO 1.2 – Proper rolling of two pieces without slipping

- **Content/Topic 1 Introduction to rolling of two pieces without slipping**

  - **Definitions**

Links or elements and their types

Link or element: It is the name given to anybody which has motion relative to another. All materials have some elasticity. A rigid link is one, whose deformations are so small that they can be neglected in determining the motion parameters of the link**.**

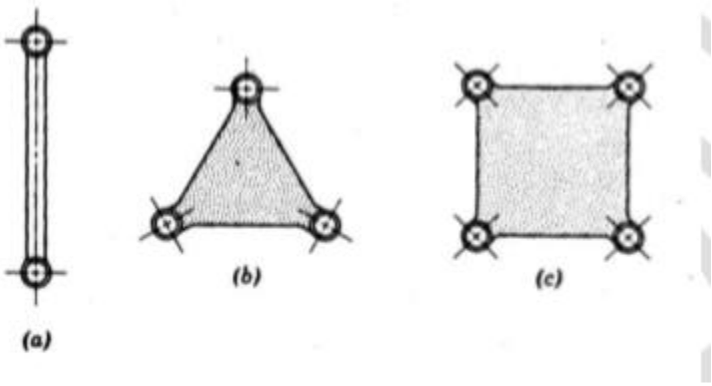


Figure 3 : link

Binary link: Link, which is connected to other links at two points. (Figure3 a)
Ternary link: Link, which is connected to other links at three points. (Figure3 b)
Quaternary link: Link, which is connected to other links at four points. (Figure3 c**)**

- **Content/Topic 2 Application of kinematic technology**

Kinematic pairs and their types

Pairing elements: the geometrical forms by which two members of a mechanism are joined together, so that the relative motion between these two is consistent are known as pairing elements and the pair so formed is called kinematic pair. Each individual link of a mechanism forms a pairing element.

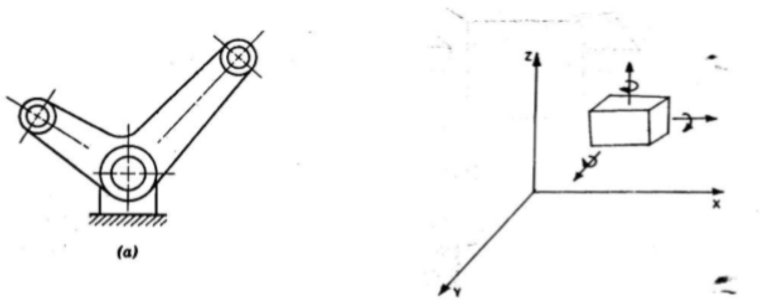


Figure 4: kinematic pair

- **Types of kinematic pairs**

(i) Based on nature of contact between elements:

a) Lower pair. If the joint by which two members are connected has surface contact, the pair is known as lower pair. Eg. pin joints, shaft rotating in bush, slider in slider crank mechanism

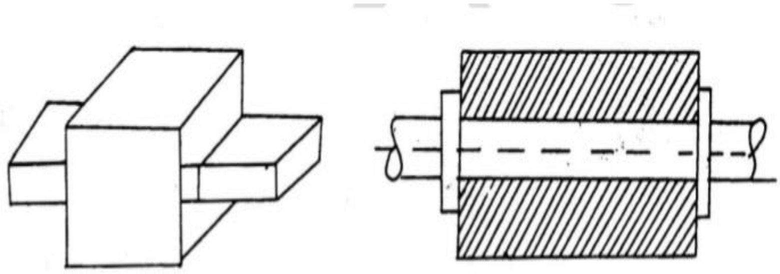


Figure 5: lower pair

b) High pair: If the contact between the pairing elements takes place at a point or along a line, such as in a ball bearing or between two gear teeth in contact, it is known as a higher pair.

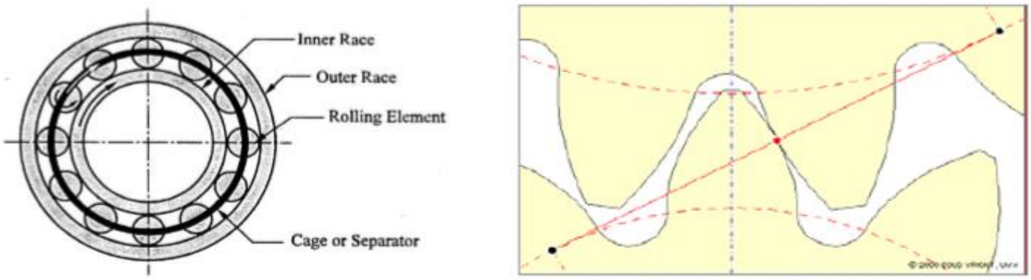


Figure 6 : high pair

(ii) Based on relative motion between pairing elements:

(a) Sliding pair. Sliding pair is constituted by two elements so connected that one is constrained to have a sliding motion relative to the other. DOF = 1

(b) Turning pair (revolute pair). When connections of the two elements are such that only a constrained motion of rotation of one element with respect to the other is possible, the pair constitutes a turning pair. DOF = 1

(c) Cylindrical pair. If the relative motion between the pairing elements is the combination of turning and sliding, then it is called as cylindrical pair. DOF = 2

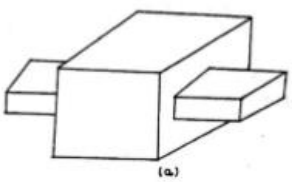


Fig.1.8 Sliding pair

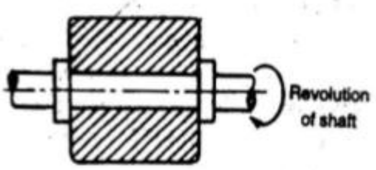


Fig.1.9 Turning pair

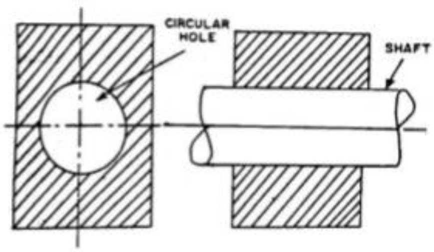
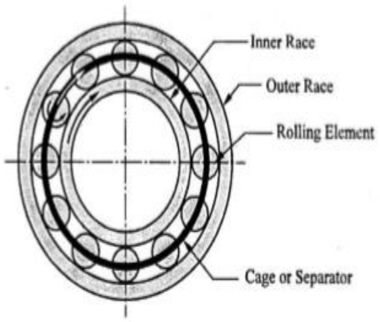


Fig.1.10 Cylindrical pair

Figure 7: cylindrical pair

(d) Rolling pair. When the pairing elements have rolling contact, the pair formed is called rolling pair. Eg. Bearings, Belt and pulley. DOF = 1



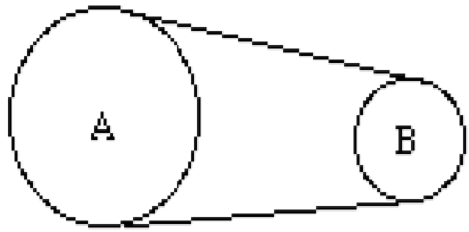


Figure 8: Belt and pulley

(e) Helical pair or screw pair. When the nature of contact between the elements of a pair is such that one element can turn about the other by screw threads, it is known as screw pair. Eg. Nut and bolt. DOF = 1

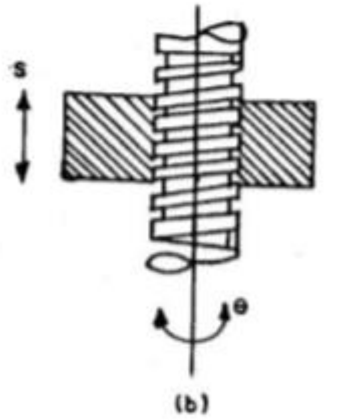


Fig.1.13 Screw pair

Figure 9: screw pair

(iii) Based on the nature of mechanical constraint.

(a) **Self-Closed pair**. Elements of pairs held together mechanically due to their geometry constitute a closed pair. They are also called form-closed or self-closed pair.

(b) **Unclosed or force closed pair.** Elements of pairs held together by the action of external forces constitute unclosed or force closed pair .Eg. Cam and follower.

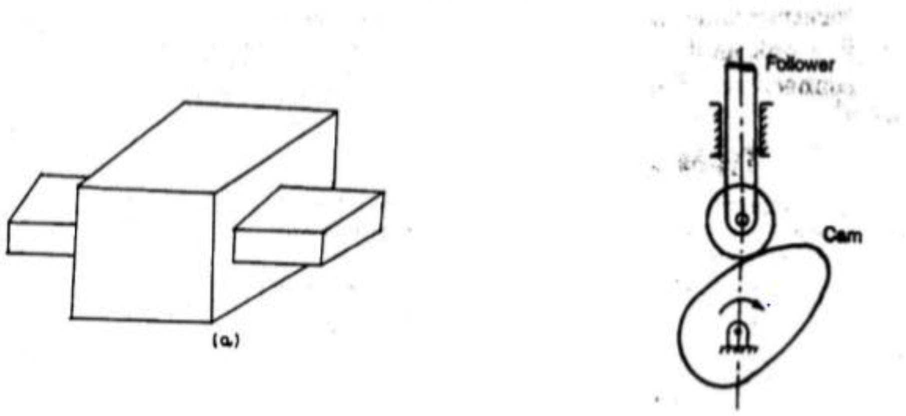


Figure 10: cam and follower

LO 1.3 – Apply kinematic pairs

- <u>**Content/Topic 1definitions of kinematic**</u>

    ➢ <u>**Proper application of kinematic pair**</u>

This is applied mostly in power transmission where power can be transmitted from one point to another.

Mode of power transmission

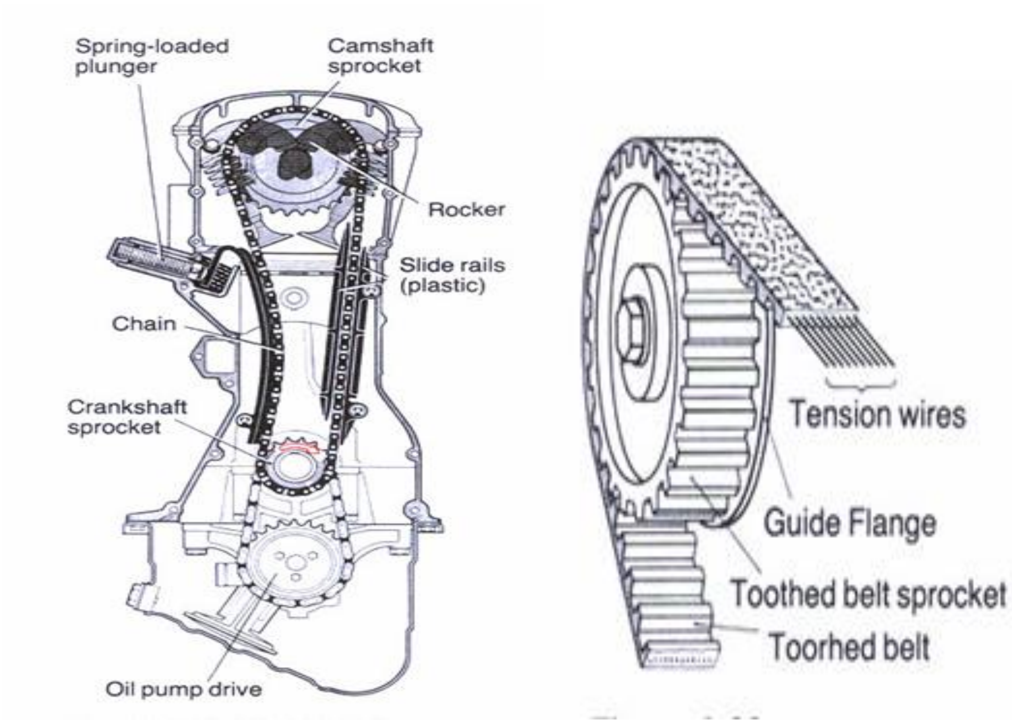


figure 11: toothed belt

- **Content/Topic 2 Proper application in automotive technology**

These are also applied where we want to engage one pieces or more to drive or to put another pieces in motion . here there is an example

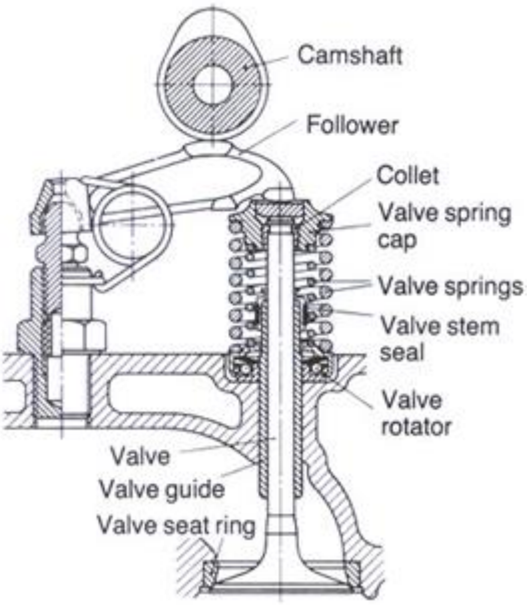


Figure 12: com and flower

When camshaft rotate, the com pushes or releases o flower to open and close the valve.

Learning Unit 2 – Apply Forces

LO 2.1 – Describe forces

- **Content/Topic1.definitions of forces**

Definition of force is an effect that changes, or tends to change, the state of rest or uniform motion of an object. For example, if a steel block is resting on a flat surface it can be moved by the application of a force. If the steel block is bolted to the surface, the application of the same force will tend not to move it. If an object such as a trolley is moving at steady speed across a surface the application of force in the direction of travel will cause it to move faster. The unit of force is the newton (N). 1 newton is the force that will produce an acceleration of 1m/s2 when applied to a mass of 1kg that is free to move.

- **Content/Topic 2Identification of forces**

Types of force

- **Direct forces**: these may be a push or a pull. In the case of the steel block, the pull may be exerted by means of a cord attached to the block – in the case of a push; the force would be applied by means of a solid rod.
- **Attractive forces**: the collective force exerted by a magnet or the gravitational effect of the earth. The force of gravity is exerted by the earth on all objects on, or near, its surface

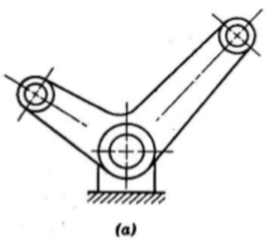
and tends to pull such bodies towards the earth's Centre. The weight of an object is a measure of the gravitational force acting on it.

- **Explosive forces:** the collective force exerted by the rapidly expanding gases in an engine cylinder following combustion.

- **Content /Topic3.Application of force in automotive technology**

Kinematic pairs and their types

Pairing elements: the geometrical forms by which two members of a mechanism are joined together, so that the relative motion between these two is consistent are known as pairing elements and the pair so formed is called kinematic pair. Each individual link of a mechanism forms a pairing element.



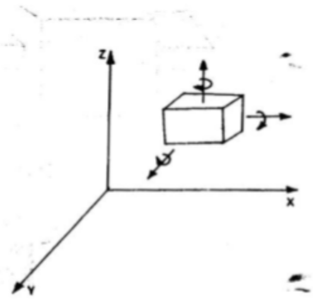


Figure 13: kinematic pair

LO 2.2 – Apply graphical representation of forces

- **Content/Topic 1 Graphical representation of forces and diagram**

All of the features of a force can be represented graphically by a line. The line is drawn so that its length represents the magnitude of the force. The direction of the line, for example 50to the horizontal, represents the direction of the force. An arrow drawn on the line represents the sense – push or pull.

Example Represent the following forces acting at a common point (see Figure 5.1).

(a) 30N pulling away from the point, direction due north;
(b) 20N pushing toward the point, direction due west;
(c) 15N pulling away from the point, direction south west;
(d) 40N pushing towards the point, direction 40west of north.

- **Content/Topic 2 Vector diagram**

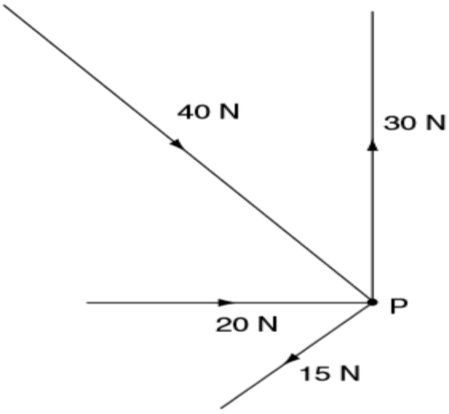


Figure 14: diagram of force

LO 2.3 – Apply addition of forces

- **Content/Topic 1Identification of forces Resultant**

Proper application of Addition of forces

Fig. 5.2 Addition of forces – the resultant

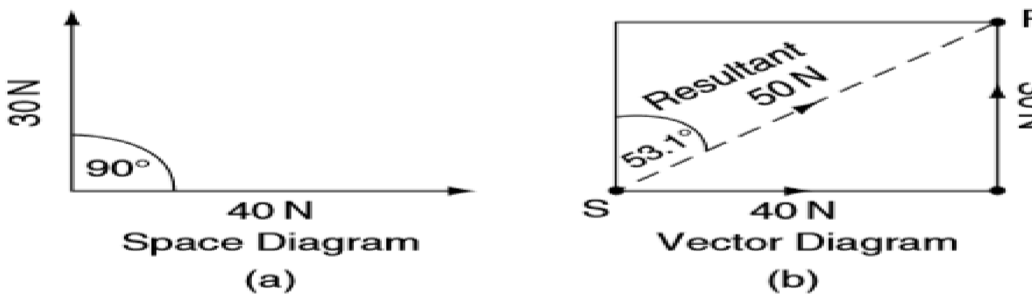


Figure 15: Addition of force

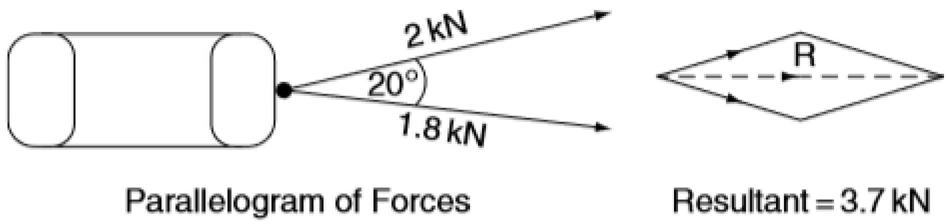
When two forces act at a point so that both are directly in line, their combined effect can be found by adding the forces together. In Figure 15(a), the combined effect (resultant) of the two forces of 50N is

100N in the same direction. In Figure 15(b) the forces are in opposition 50N horizontally to the left and 80N horizontally to the right. The combined effect (resultant) is a force of 30N to the right. The resultant of two or more forces acting at a point is the single force that would replace the others and produce the same effect. When the forces are not in line as shown by the space diagram in Figure 15(a), the procedure for finding the resultant is slightly more complicated and requires the use of vectors. A vector is a line that represents a quantity such as a force. The length of the line represents the size of the force, the arrow represents the sense of the force, push or pull, and the angle of the line represents the direction of action of the force. To add vectors in order to find the resultant the vectors are drawn parallel to the lines of action of the forces. An S is placed at the point where the drawing of the vector diagram starts. From S the first vector is drawn in the required direction, the next vector is drawn from the end of this first vector, and when the last vector has been drawn an F is placed at the end of the final vector. A line is then drawn from S to F, an arrow pointing from S to F is placed on this line and this line (vector) represents the resultant. In the example shown in Figure 5.3(b) the resultant is a 50N pull acting at an angle of 531east of north.

- **Parallelogram of forces**

If three concurrent, coplanar forces are in equilibrium, two of the forces may be represented by two sides of a parallelogram. If the parallelogram is completed by drawing in the other two sides, the diagonal drawn from the angular point formed by the adjacent sides will represent the third force in magnitude and direction.

Figure 16: parallelogram force



Example 5.1

Find the resultant of two forces acting at a point: (1) a 45kN pull acting in a horizontal direction and (2) a 30kN pull acting at an angle of 60to the horizontal (see Figure 5.5).

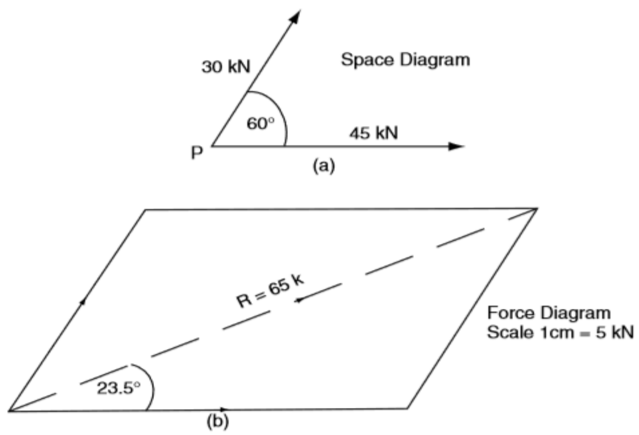


Figure 17: Resultant force

Learning Unit 3 – Apply Leverage and gears trains

LO 3.1 – Apply torque multiplication

- **Content/Topic 1 Definition of torque**

The term torque is define as rotary force and is simply the product of for

Ce and the effective radius.

We have: T=F×D

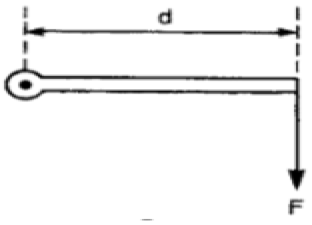


Figure 18: component of torque

- **Content/Topic 2 Identify clearly torque multiplication**

  Torque multiplication achieved when length in which the forces is being applied is extended. In this case, it is not necessary to add the applied force only extend the length.

  Levels

  Leverage and the use of levers occurs in the use of tools such as spanners, pry bars, pliers etc., and in many vehicle mechanisms such as clutch and brake pedals, throttle linkages and suspension units.

Principles of leverage

The basic principles of leverage are covered by a rule that is known as the principle of moments.

- **Torque multiplication by gears**

The torque required at the driving road wheels of a vehicle is larger than the torque available at the engine flywheel. For example, the engine of a medium-sized family saloon may develop a torque of100Nm and require a torque of 1500Nm at the driving wheels. This would require a torque multiplication of 15 times the engine torque. In order to operate the vehicle it is necessary to provide some means of multiplying engine torque. Use of the gears is the most commonly used method of torque multiplication on vehicles.

The figure below shows a pair of gears and their action may be compared to the action of two simple levers. The radius of each gear is related to the number of teeth on the gear. In this example the radius of the large gear may be taken as 40mm and that of the small gear as 10mm. The gear ratio = revolutions of input gear/revolutions of output gear

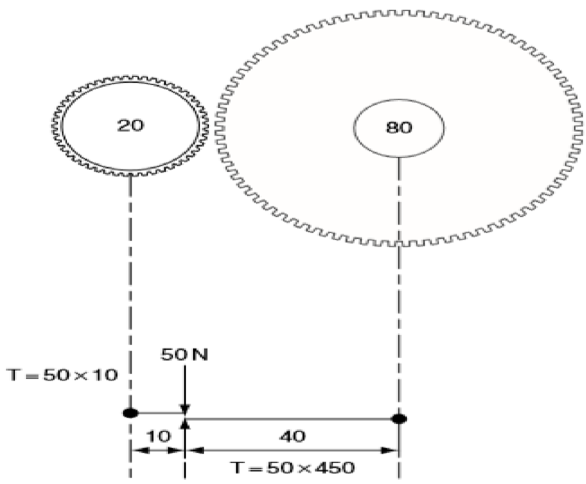


Figure 19 :Torque multiplication

In this case the small input gear must rotate four times to produce one revolution of the large output gear. The gear ratio in this case is 4:1. If the small gear is the input gear that carries a torque of 50N×10mm=500N mm; the torque on the large gear=50N×40mm=2000N mm. This simple pair of gears provides a torque multiplication of 4.

- **Content /Topic3 Application and examples in automotive mechanics**

Torque is a turning effect; a clear demonstration of the meaning of torque may be seen in the widely used torque wrench that is used for tightening nuts and bolts to a preset value, as shown in Figure 7.10. Torque is the product of force and perpendicular distance from the center of rotation to the line in which the force is acting.

- **APPLICATION 1**

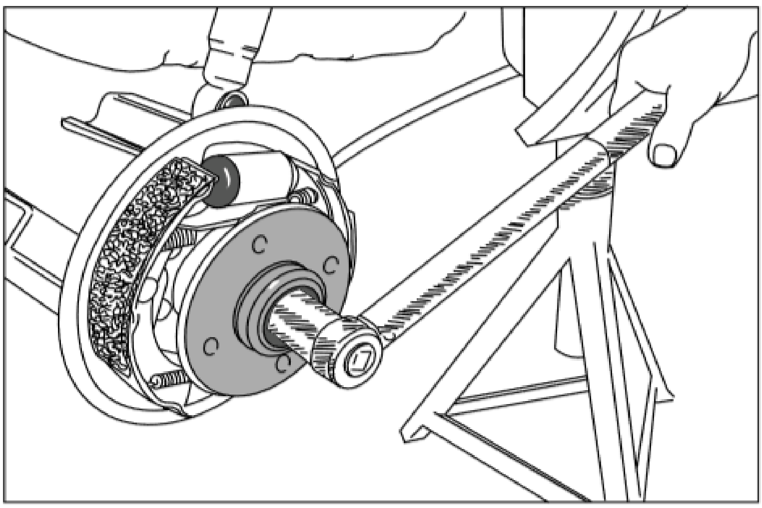


Figure 20:torque wrench

Example 7.7 in the example of the torque wrench, the torque may be calculated as follows. Assume that the hand force is applied at right angles to the shaft of the torque wrench and that the force is applied at a distance of 40cm from the center of the axle. In this particular case the torque required is 25N m. Calculate the force F required to produce this amount of torque.

In this case we have:

Torque (T) = 25N m;

Radius (R) =40cm=0.4m.
T=F×R
F=T÷R F= 25N m 0
4m F=625N

- **APPLICATION 2**

Engine torque

Engine torque is produced by the action of the gas force on the piston which is transmitted to the crankshaft through the connecting rod. The principle is shown in Figure 7.12.

Example 7.8 in this case, the effective force on the connecting rod is 2000N and the connecting rod is making a right angle with respect to the crank throw. The throw (radius) of the crank is 60mm. The connecting rod is at a right angle to the crank throw. Here, the torque produced is:

Torque (T) =Force (F) ×Radius R F=2000N, R=60mm=006m T=F×R T=2000N×006m T=120N m Crankshaft torque T=120N m

It is important to note that the torque is calculated from the force and the perpendicular distance from the canter of rotation to the line in which the force is acting.

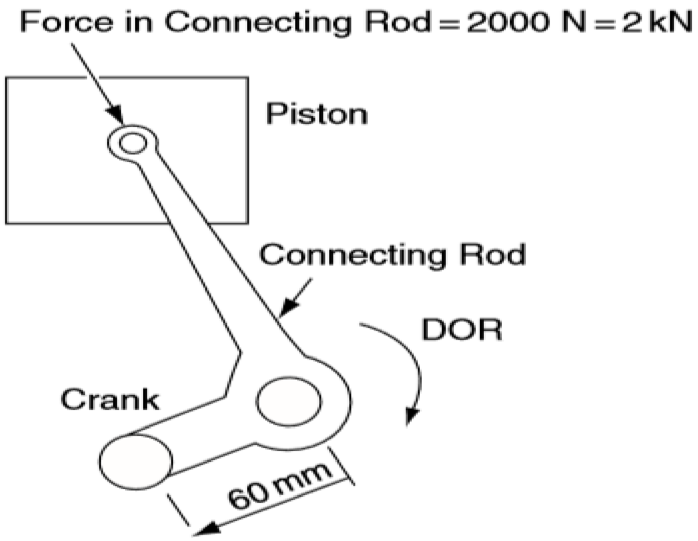


Figure 21: Engine torque

Radius of Crank = 60 mm = 0.06 m. The Connecting Rod Force is at Right Angles to the Crank Throw.
Torque = 2000 N × 0.06 m = 120N m.

The Torque = Force × Perpendicular Distance from Centre of Turn to Line of action of force

LO 3.2 – Describe Drive and driven Gears

- Content/Topic 1Identification of driver and gears

Figure 22: driver and driven gear

Driver gear: is a gear, which is assigned to drive another gear
Driven gear: is a gear, which is take motion from a driver gear. In other words is driven by driver.

- **Content/Topic 2 Application and examples in automotive mechanics**

Gear train is one of the toque transmission methods. Here we can take an example:

1. Variable speed gearbox.
2. Internal gear pumps
3. Engine drive where the motion is transmitted by gears.

LO 3.3 – Determine gear ratio

- **Content/Topic 1 Calculation of gear ration**

When you consider the driven gear to the driver gear ratio that ratio is known as Gear ratio or Transmission ratio, the driver gear to the driven gear ratio is known as torque ratio.

Gear ratio= Output/Input

Gear output is the number of teeth on the driven gearwheel, and input is the number of teeth on the driving gearwheel

Grear ratio = driven/driver

For example, in the figue 18.4 two gearwheels are meshed in contact with each other. Gearwheel A (the driver) has 15 teeth and garwheel B (the driven gear) has 30 teeth.

Gear ratio=driven/driver = 30/15=2/1=2:1

- **Content/Topic 2 Applications and examples in automotive mechanics**

The principle of gear ratio is applied on automotive gearbox, in starting system,

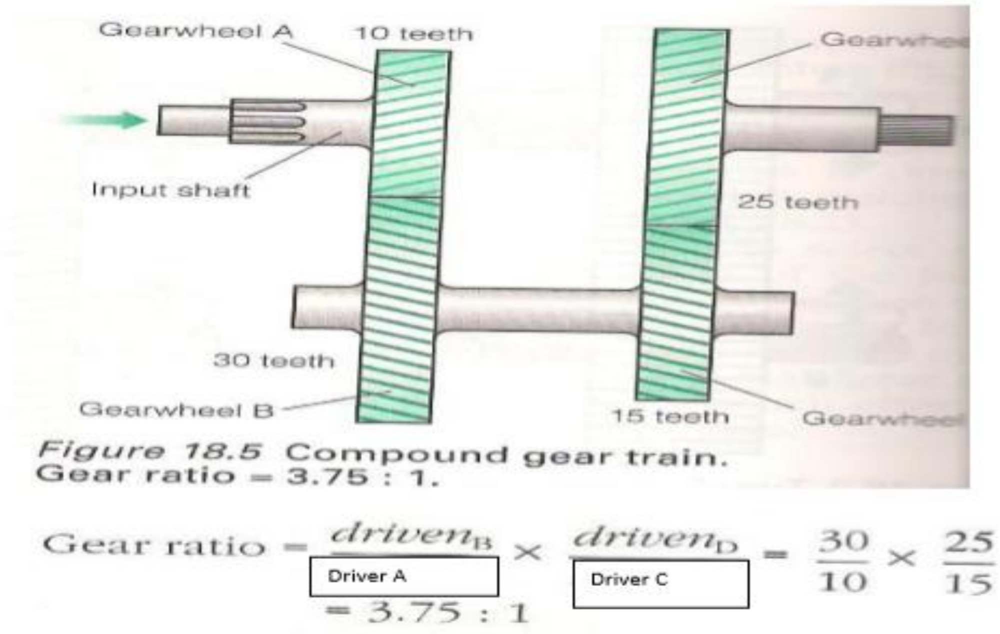


Figure 23: Gear ratio

Learning Unit 4 – Apply Friction

LO 4.1 – Apply coefficient of friction

- **Content/Topic 1 Definitions**

Friction: is rubbing of one object or surface against another. And is physically defined as a force that resists the relative motion or tendency to such motion of two bodies in contacts.
Friction force: is a tangential force acting on the object that oppose the sliding of the object on an adjacent surface with which it is in contact.
Friction force is parallel to the surface and opposite to the direction of motion.
Coefficient of friction:
Experiment shows that when a body is at rest, the frictional force to be overcome before it moves, called limiting friction, is greater than that which acts once it is moving, called sliding, kinetic or dynamic friction (all terms are used)

The laws of friction, which hold approximately, can be summarized as follows:

1. The limiting frictional force F is directly proportional to the normal force N exerted by the surface on the body (which equals the weight of the body), I.e. $F \alpha N$ or F/N = constant.

2. The dynamic frictional force F' is directly proportional to the normal force N, I.e. $F' \alpha N$ or F'/N= constant, and is reasonably independent of the speed of motion.

3. The frictional force does not depend on the area of contact of the surfaces if the normal reaction is constant.

The coefficients of limiting and dynamic friction are denoted by μ and μ' respectively and are defined by the equations. $\mu = F/N$ and $\mu' = F'/N$

In general, a surface exerts a frictional force, and the resultant force on a body on the surface has two components - a normal force N perpendicular to the surface and a frictional force F along the surface. If the surface is smooth, as is sometimes assumed in mechanics calculations, $\mu = 0$ and so $F = 0$. Therefore, a smooth surface only exerts a force at right angles to itself. i.e. a normal force N.

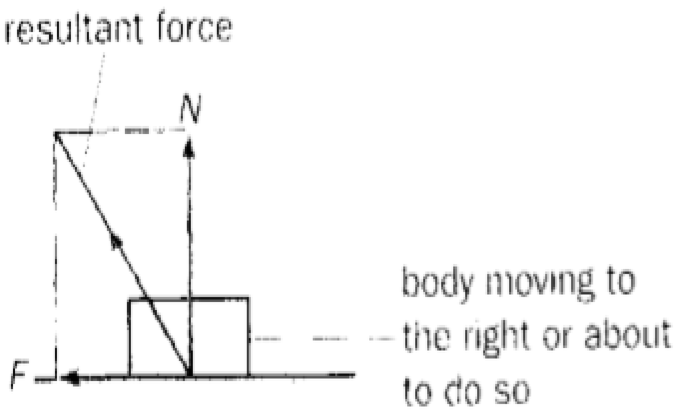
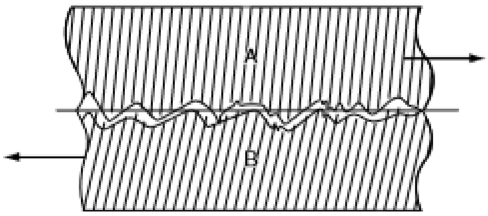


Figure 24: Friction force

The coefficient of limiting friction μ can also be found by placing the block on the surface and tilting the latter to the angle θ at which the block is just about to slip. The three forces acting on the block are its weight mg the normal force N of the surface and the limiting frictional force F ($= \mu N$). They are in equilibrium and if mg is resolved into components $mg \sin \theta$ along the surface and $mg \cos\theta$ perpendicular to the surface. Then, $F = \mu N = mg \sin \theta$ and $N = mg \cos\theta$ Dividing. $\mu = \tan \theta$ Hence μ can be found by measuring θ, called the angle of friction.

- **Content/Topic 2 Applications in automotive sciences**

Surfaces which appear to be quite smooth are, when minutely examined, normally found to have surface irregularities and imperfections. When two such surfaces are made to slide, one over the other, these surface imperfections cause resistance to motion. This resistance to motion is called friction. In Figure 9.1(a) the surface imperfections are enlarged. The peaks of the imperfections slot into valleys and as one surface moves over the other the force causing movement attempts to break the peaks off; this causes the resistance to movement that is known as friction and also results in wear and deposition of particles in surrounding parts of any mechanism. Figure 9.1(b) shows the same surfaces separated by a layer of oil. The layer of oil separates the surfaces so the one may slide over the other with reduced resistance to movement; lubrication also reduces wear.



(a) xxx Surfaces

Figure 25 : friction force

- **Coefficient of friction**

  The apparatus shown in Figure 9.2 is used to determine the coefficient of friction. The block W is loaded with suitable weights. Other weights are then placed in the small weight pan and the amount is increased until W moves steadily across the flat surface on which it is placed. The weight of W (in newton's) represents the force pressing the block on to the flat surface and the weight in the pan represents the force F (in newton) that

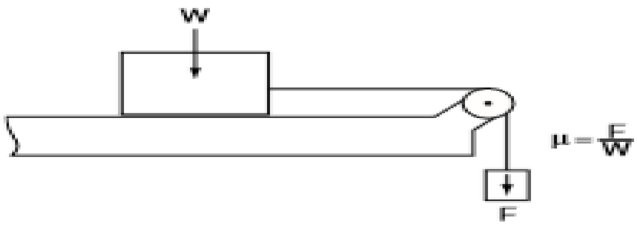
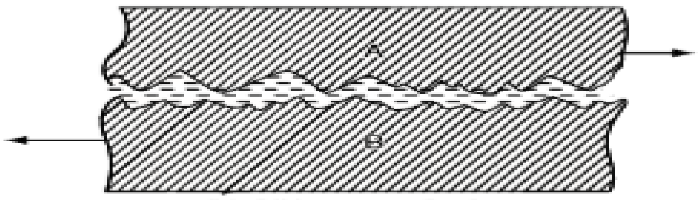


Fig. 9.2 Friction experiment



(b) Oil between Surfaces

Figure 26: coefficient of friction

Causes the block W to move steadily along the flat surface. The ratio of F to W is called the coefficient of friction and it is denoted by the symbol.

Coefficient of friction =F W (9.1)

Where F is the force to move the block and W is the force pressing the surfaces together.

Example: In an experiment to determine the coefficient of friction between brake lining material and steel, a force of 60 newton steadily moves a block lined with the brake lining material across a steel surface. The block weighs 100 newton. Calculate the coefficient of friction.

μ=F/W

F =60newtons

W=100newtons

μ =60/100

μ =0.6

LO 4.2. Determine static friction

- **Content/Topic 1 Definitions**

Static friction is the force required to cause initial movement against friction is greater than the force required to maintain uniform motion.

- **Content/Topic 2 Applications and examples in automotive mechanics**

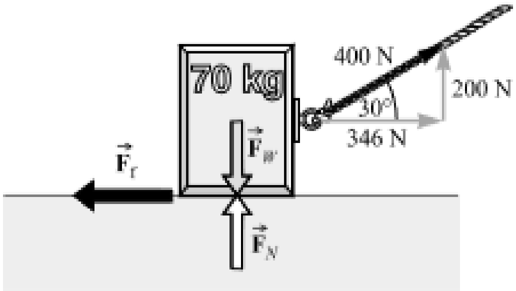


Fig. 3-8

Because the box does not move up or down, we have $\Sigma F_y = ma_y = 0$. From Fig. 3-8, we see that this equation is

$$F_N + 200\text{ N} - mg = 0$$

But $mg = (70\text{ kg})(9.81\text{ m/s}^2) = 687\text{ N}$, and it follows that $F_N = 486\text{ N}$.

We next find the friction force acting on the box:

$$F_f = \mu_k F_N = (0.50)(486\text{ N}) = 243\text{ N}$$

Now let us write $\Sigma F_x = ma_x$ for the box. It is

$$(346 - 243)\text{ N} = (70\text{ kg})(a_x)$$

from which $a_x = 1.5\text{ m/s}^2$.

LO 4.3- Determine sliding friction

- **Content/Topic 1Deginitions**

Sliding friction

The sliding force of friction is also known as kinetic friction, is define as the force that required keeping surface sliding along another. The sliding force of friction is directly proportional to the force pressing the surfaces together

This force is slightly less than the static friction force

- **Content/Topic 2 Applications and examples in automotive mechanics**

Making use of friction Clutch

A good example of application of friction in automotive technology is clutch in transmission line where clutch disc transmit torque and speed from engine to the gearbox

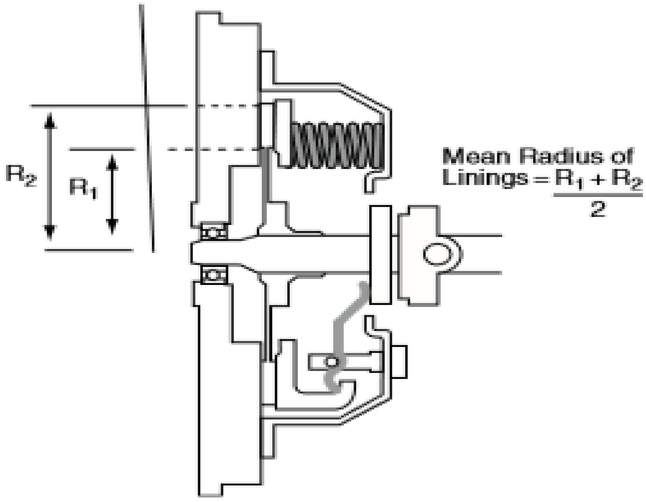


Figure 27: clutch system

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Learning Unit 5 – Apply Pressure

LO 5.1 – Apply Pascal is low

- Content/Topic 1Definitions

When substances such as gases and fluids are in a cylinder or similar container, and they have a force applied to them, they are said to be under pressure, or pressurized. In SI units, the unit of pressure is the newton per square meter. 1N/m2 is known as a Pascal. A Pascal is a very small unit in vehicle engineering terms and it is common practice to use a larger unit of pressure, which is known as a bar: 1 bar=100000N/m2. In vehicle engineering, it has been common practice to set the operating pressure of diesel engine fuel injectors in units of pressure known as atmospheres. One atmosphere is approximately 14.7 pounds per square inch and is approximately equal to the pressure exerted by the atmosphere, at sea level. One bar is approximately equal to one atmosphere. Pressure calculation. Pressure = Force in newton (N) divided by area in square meters (m^2).

- Content/Topic 2 Applications in automotive technology

EXAMPLE:

A force of 600N is applied to a piston which has a cross-sectional area at the crown of 001m2, as shown in Figure Bellow. Calculate the pressure that this force creates in the gas in the cylinder.

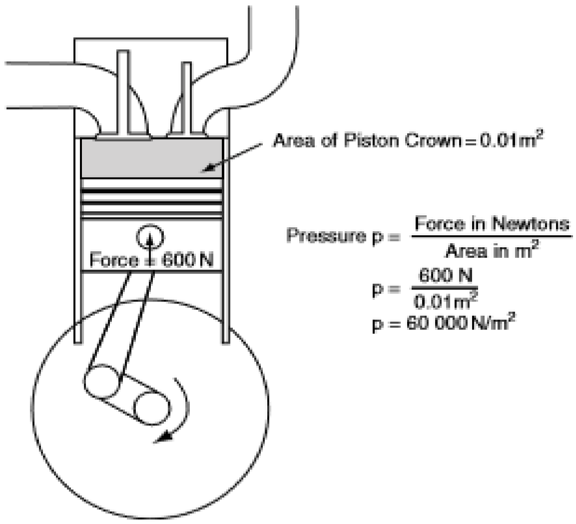

Figure 28: Engine torque

PASCAL'S LAW

The pressure exerted anywhere in a mass of confined liquid is transmitted undiminished in all directions throughout the liquid.

It also states that: in enclosed hydraulic system, the pressure is transmitted equally and in all direction. **It is applied in hydraulic braking system of vehicle. As is shown in the following diagram**

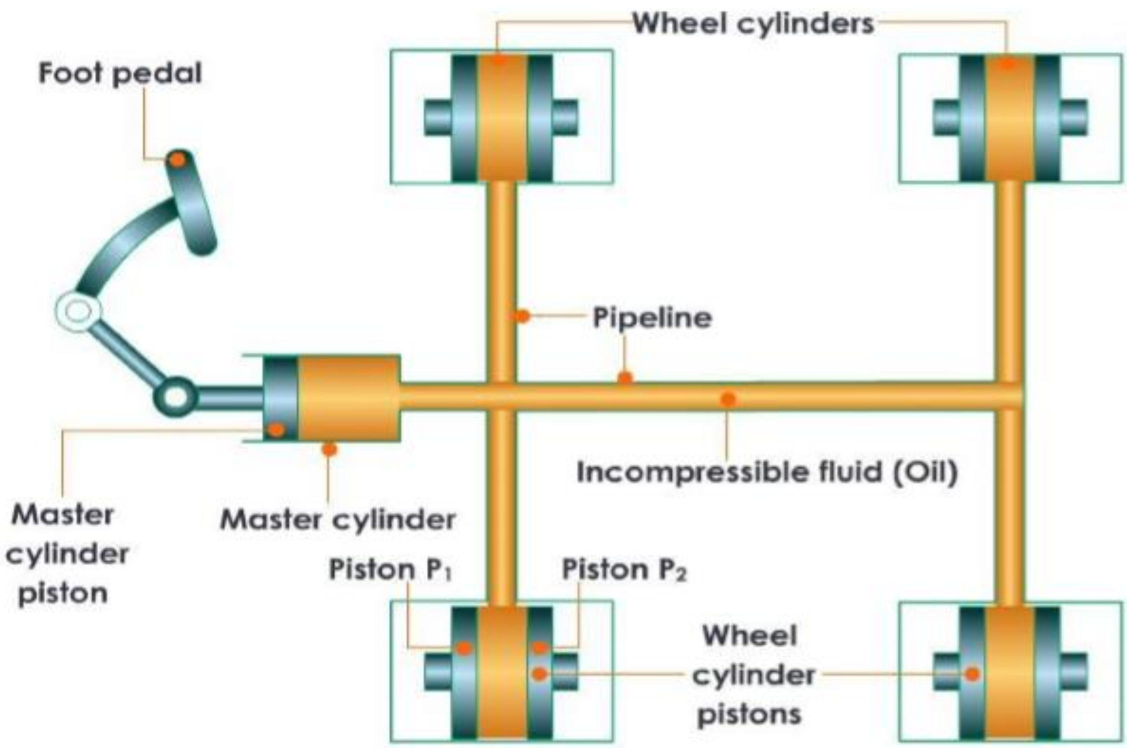

Figure 29: hydraulic brake system

LO 5.2. Apply pressure in hydraulic systems

- **Content/Topic1 Definitions**

Hydraulic systems rely on the fact that the pressure inside a closed vessel is constant throughout the vessel. Figure bellow shows a closed vessel that has a number of pistons located in it. The pressure on each piston (not the force) is equal.

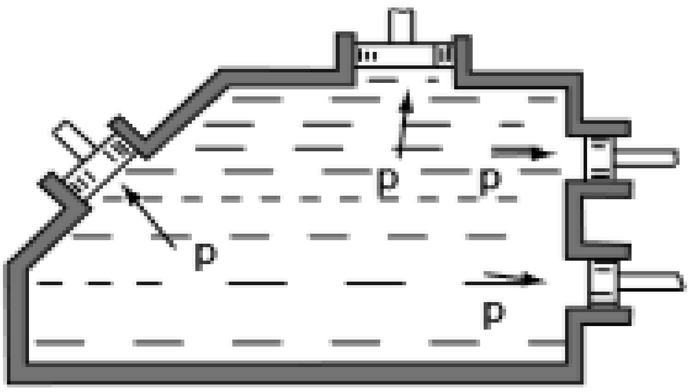

Figure 30: pressurized vessel

- **Content/Topic 2 Applications and examples in automobile technology**

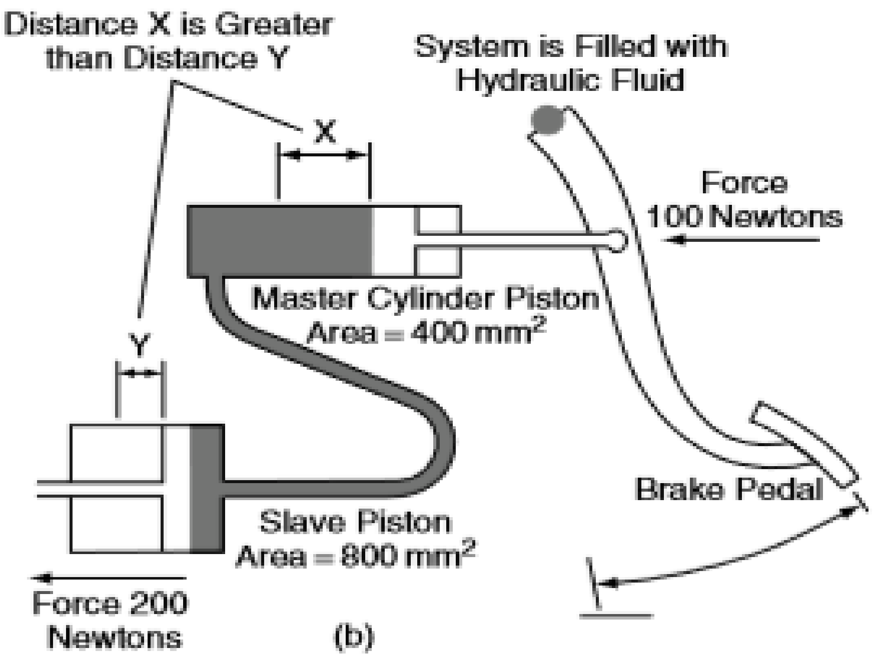

Figure 31: Hydraulic clutch system

Pressure is applied in various automobile system, especially on the system which operated by fluid (air or oil).

Ex:

- ✓ Hydraulic brake system
- ✓ Hydraulic clutch control
- ✓ Compressed air brake system
- ✓ Hydraulic steering system

LO 5.3. Apply pressure in compressed air

- <u>**Content/Topic 1 definitions**</u>

Compressed air is air which is kept under a certain pressure by means of **air compressor**, usually greater than that of the atmosphere.
The compressed air is used for very long time; one could already use it to poke fire of forging mill (very low pressures). Or can be used for propulsion of the boats.

Pneumatic: Is study of air and other gases at rest and in motion, especially under pressure, and application of that knowledge in design and control of machines. In comparison, **hydraulics** is concerned with liquids and their behavior under pressure.

Pneumatic power is the use of compressed air as a power source for portable and stationary power tools and production machinery.

- <u>**Content/Topic 2 Applicatios in automobile technology**</u>
  This is applied by **producing pneumatic energy** by mean of **Dynamic compression** and **volumetric compression or Displacement compression.**

  I. **Dynamic compression** (conversion of the air velocity into pressure):Is the high speed given to an initial volume, that speed helps us to obtain the **compressed air**.(case of turbo compressor or turbo charger).

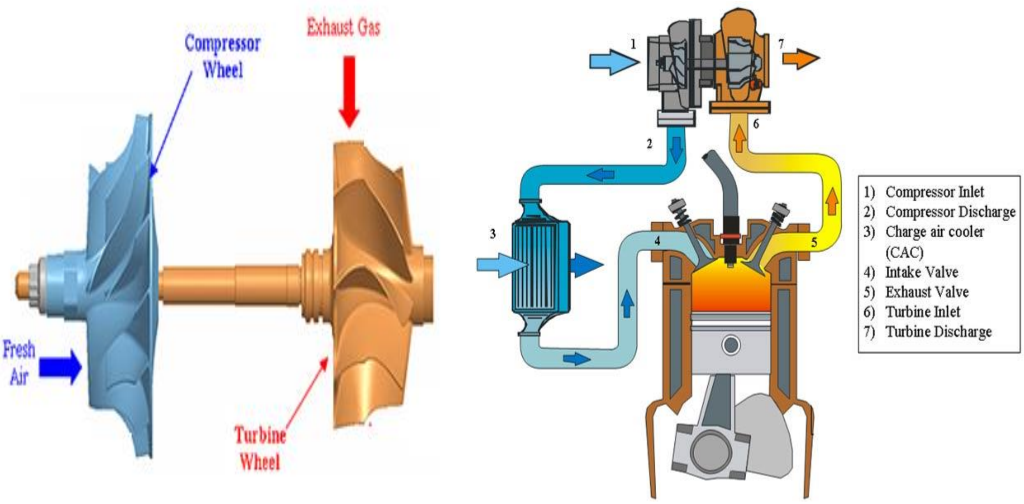

Figure 32: turbo charger

  II. **Volumetric compression or Displacement compression** (reduction of the air volume): reciprocating compressors (example of piston type compressor, which is shown below).

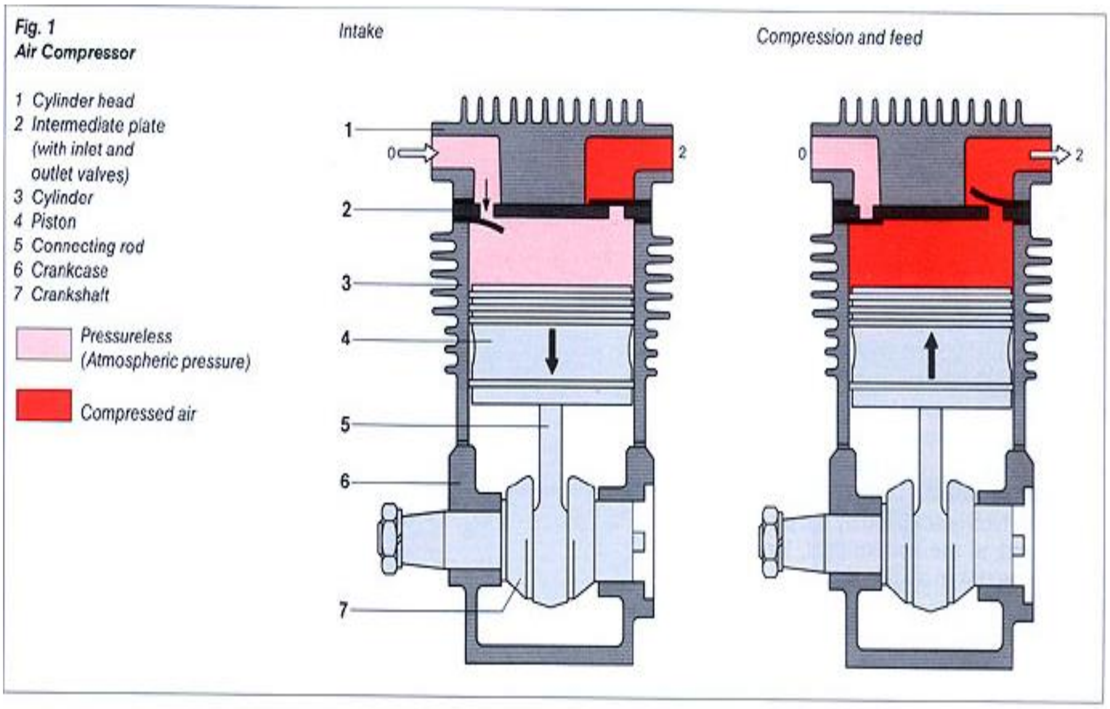

Figure 33 : Air compressor

The compressed air production includes necessary elements of compressed air treatment.

Note: In all the cases, It is necessary to provide a mechanical work to obtain this compression.

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