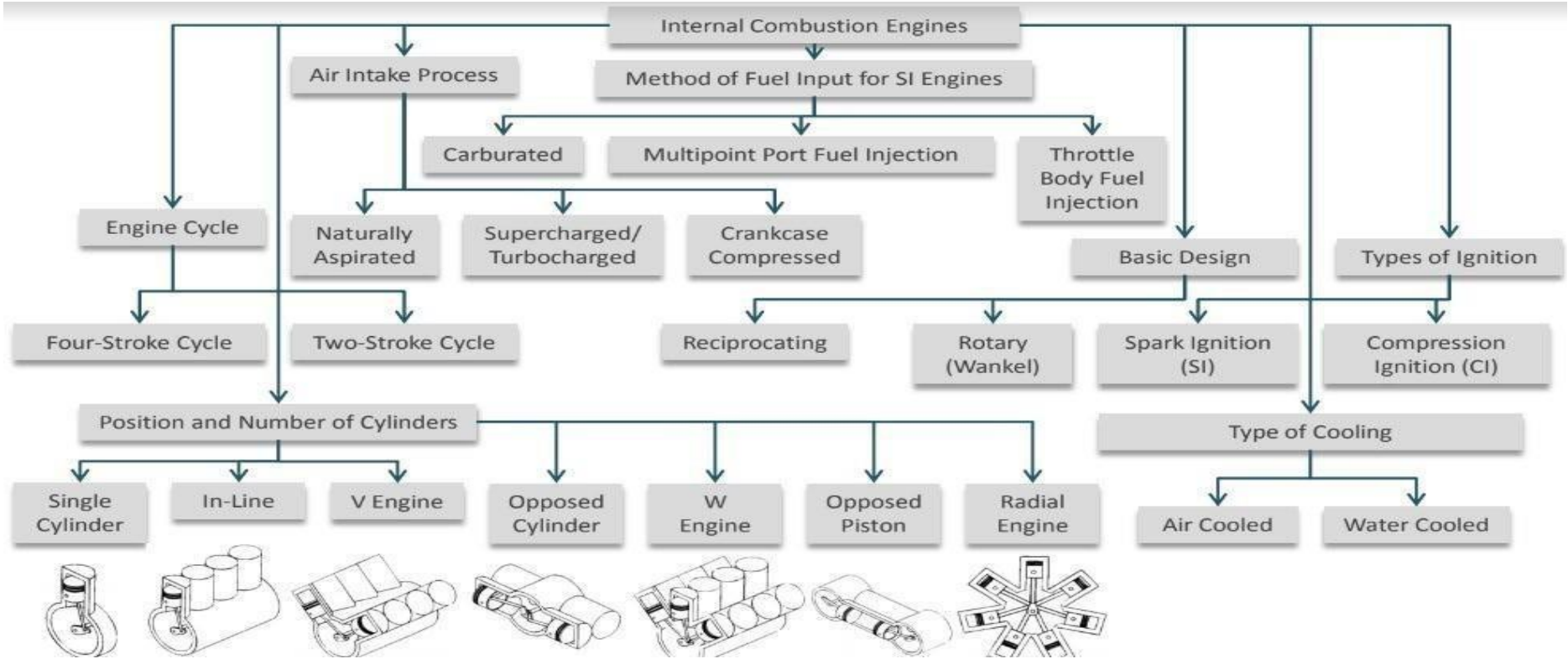
ME 165
Mechanical Engineering Fundamentals

Md. Aminul Islam
Lecturer
Department of Mechanical Engineering, BUET

Engine Classification



Engine Classification

- **Method of Ignition**
  - **Spark ignition (SI):** High-voltage electrical discharge between two electrodes ignites air-fuel mixture in combustion chamber surrounding spark plug. Example: **Petrol Engine**
  - **Compression ignition (CI):** Air-fuel mixture self-ignites due to high temperature in combustion chamber caused by high compression. Example: **Diesel engine**
- **Number of strokes per cycle**
  - **Four-stroke**: Four piston movements over two engine revolutions for each engine cycle.
  - **Two-stroke**: Two piston movements over one revolution for each engine cycle.

Engine Classification

- **The type of fuel**
  - Gasoline, Diesel or fuel oil, Gas (natural gas or methane), Liquefied petroleum gas (LPG): mainly propane, propylene, butane, and butylene
  - Alcohol (ethyl, methyl), Dual fuel (e.g. methane/diesel), Gasohol (e.g. 90% gasoline, 10% alcohol)compression.
  - Biodiesel: cleaner-burning diesel fuel made from natural, renewable sources such as vegetable oils.
- **The cycle of operation**
  - Otto cycle (also known as constant volume cycle) engine
  - Diesel cycle (also known as constant pressure cycle) engines
  - Dual combustion cycle (also known as semi-diesel cycle) engines

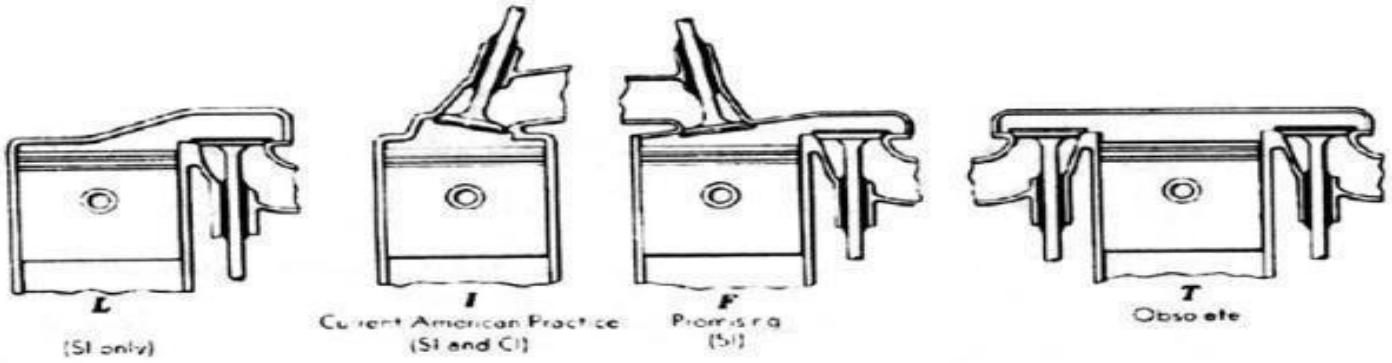
Engine Classification

- Valve location

(a) Valves in head

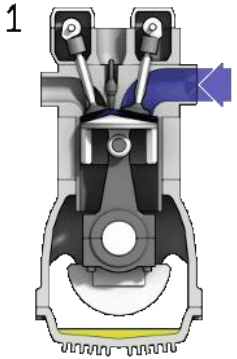
(b) Valves in block

(c) One valve in head and one in block (less common)

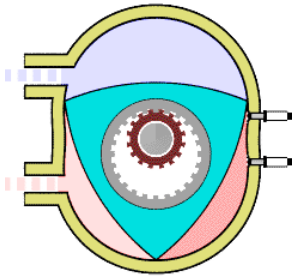


Engine Classification

- **Design**



Reciprocating



Rotary

- **Number of cylinders**

  (a) Single cylinder engines (e.g. lawnmowers),

  (b) Multi-cylinder engines.

- **The cooling system**

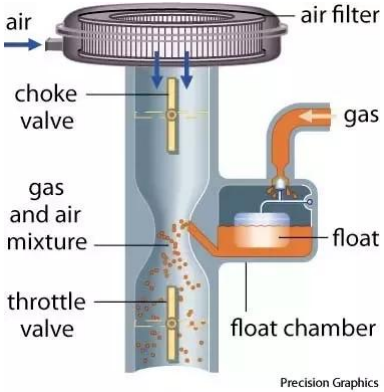
  (a) Air cooled engine, (b) Water cooled engine,

  (c) Evaporative cooling engines

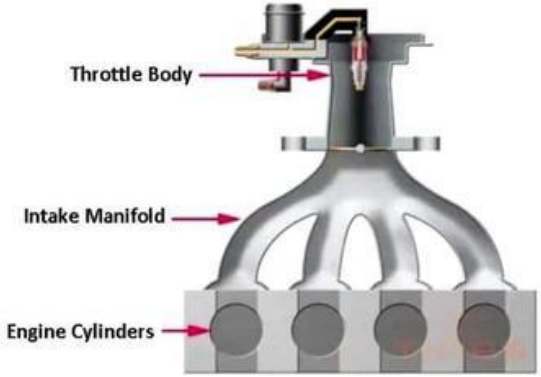
Engine Classification

- **Method of Fuel Injection**

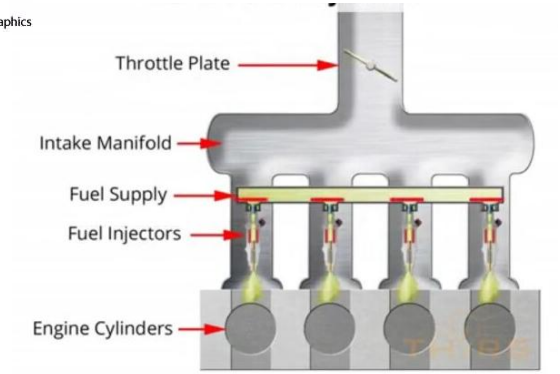
Carburetor



Throttle body Fuel Injection



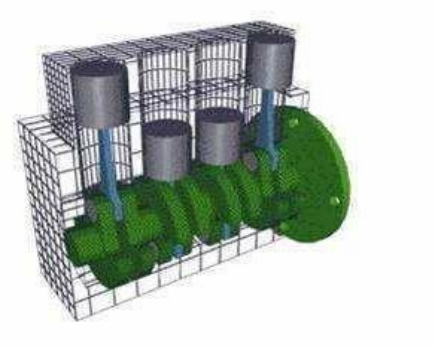
Multi port Fuel Injection



Engine Classification

- **Arrangement of cylinders:**

In-line or straight: cylinders in straight line, one behind the other in length of crankshaft.

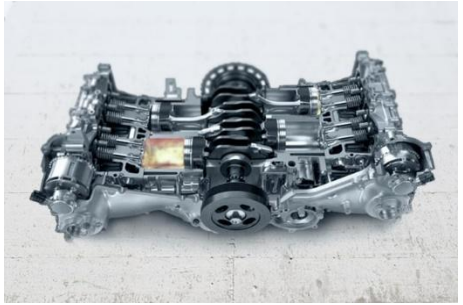


V:
two banks of cylinders at an angle with each other along a single crankshaft, angle typically 60-90^0

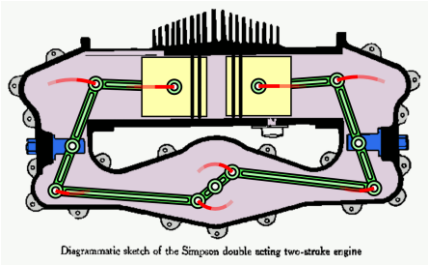
Engine Classification

- **Arrangement of cylinders:**

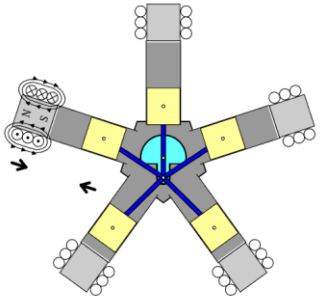
Flat or opposed cylinder (V with 180^0):
two banks of cylinders opposite each other on a single crankshaft (smallaircrafts)



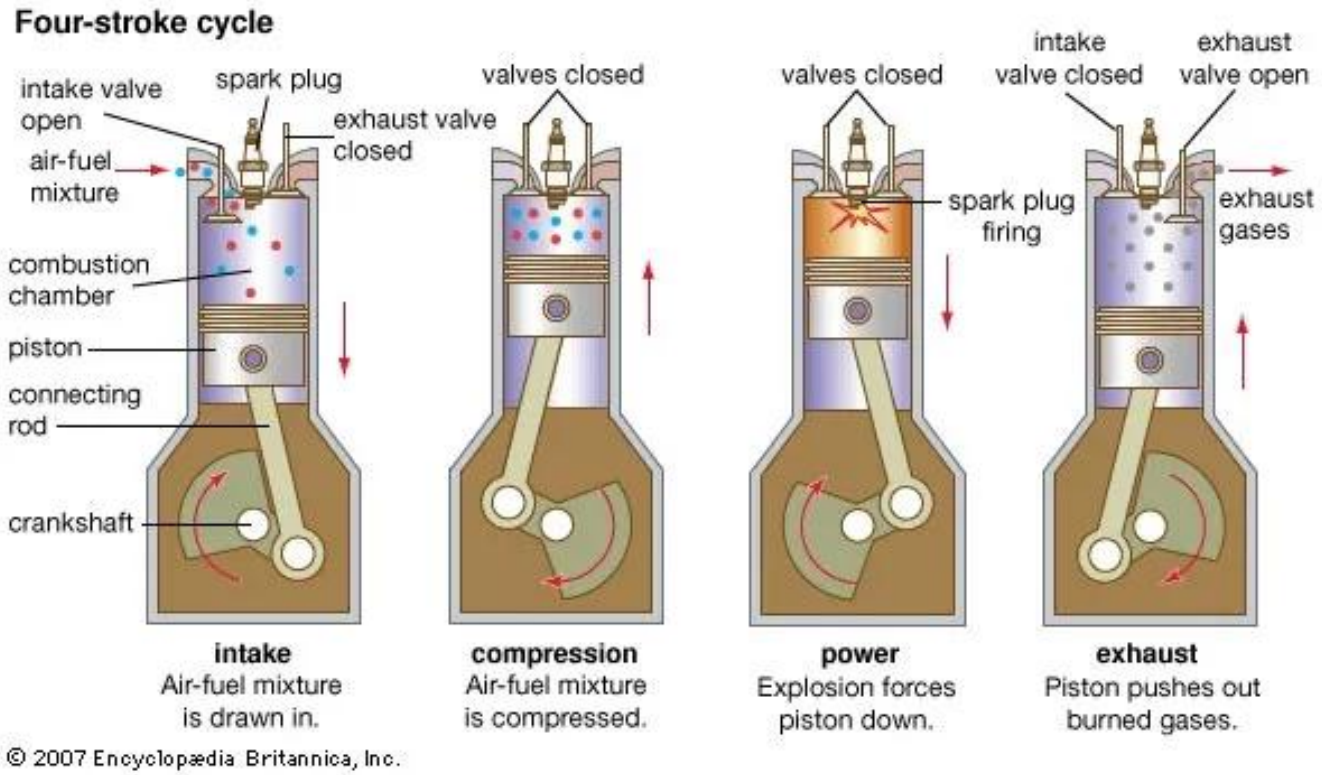
Opposed piston engine:
two pistons in each cylinder, combustion chamber between pistons



Radial engine:
cylinders positioned radially around crankshaft.



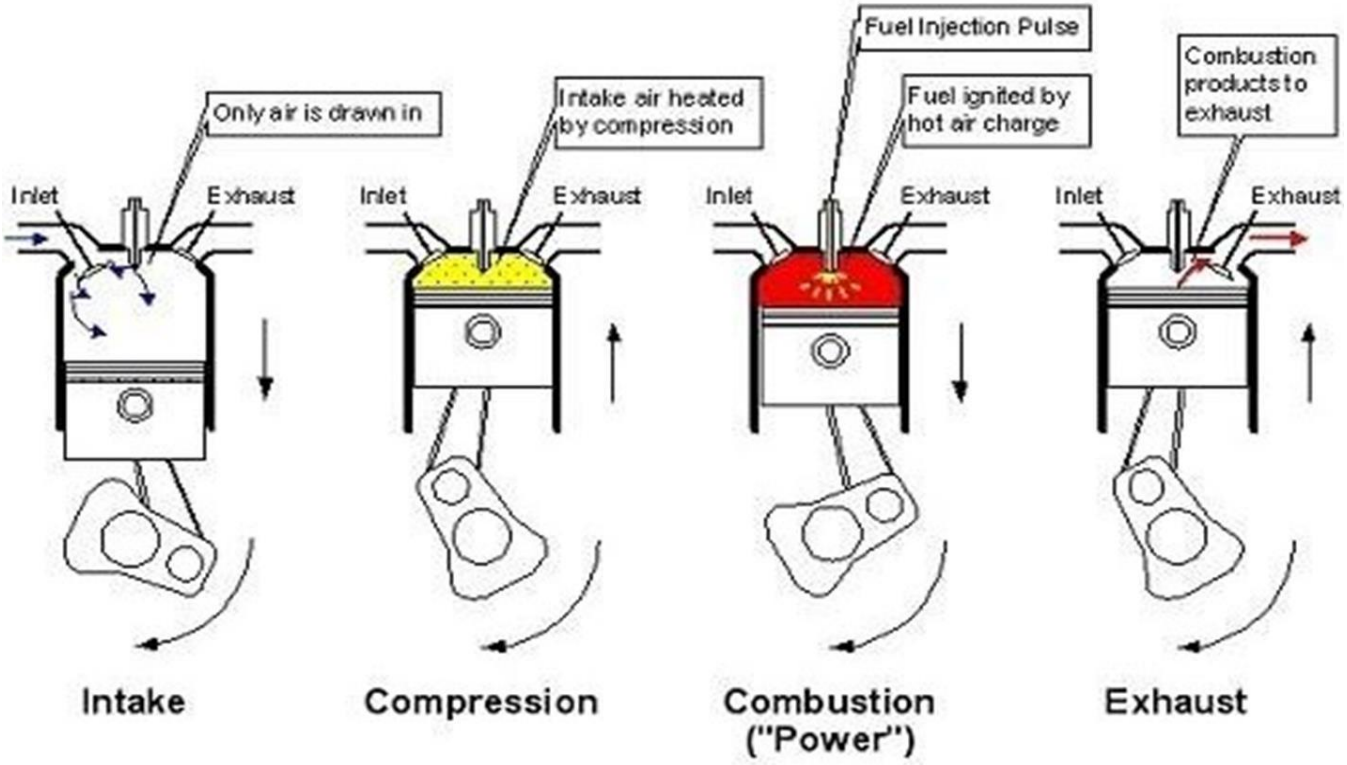
4 stroke SI (Petrol) engine operation



4 stroke CI (Diesel) engine operation

https://www.youtube.com/watch?v=fTAUq6G9apg&t=39s

4 stroke CI (Diesel) engine operation



SI vs CI

What are the differences between Petrol and Diesel Engine??

Ignition system

Compression and pressure

Compression ratio

Size of the engine

SI vs CI

SI Engine

i. Draws a mixture of air and fuel during intake

ii. Carburetor is used to mix air and fuel

iii. Pressure at the end of compression stroke around 10 bar

iv. Spark ignites the air fuel mixture

v. Compression ratio varies from 6 to 10

vi. Starting easier due to lower compression ratio

vii. Engines are lighter and cheaper due to lower compression ratio

viii. Maintenance cost low

ix. Thermal efficiency lower (around 26%)

x. Higher engine speed

xi. Used in light vehicles such as cars, motorcycles etc.

CI Engine

i. Draws only fuel during intake

ii. Injector or atomizer is used to inject fuel

iii. Pressure at the end of compression stroke around 35 bar

iv. The fuel self-ignites

v. Compression ratio varies from 15 to 25

vi. Starting difficult due to higher compression ratio

vii. Engines are heavier and costlier due to higher compression ratio

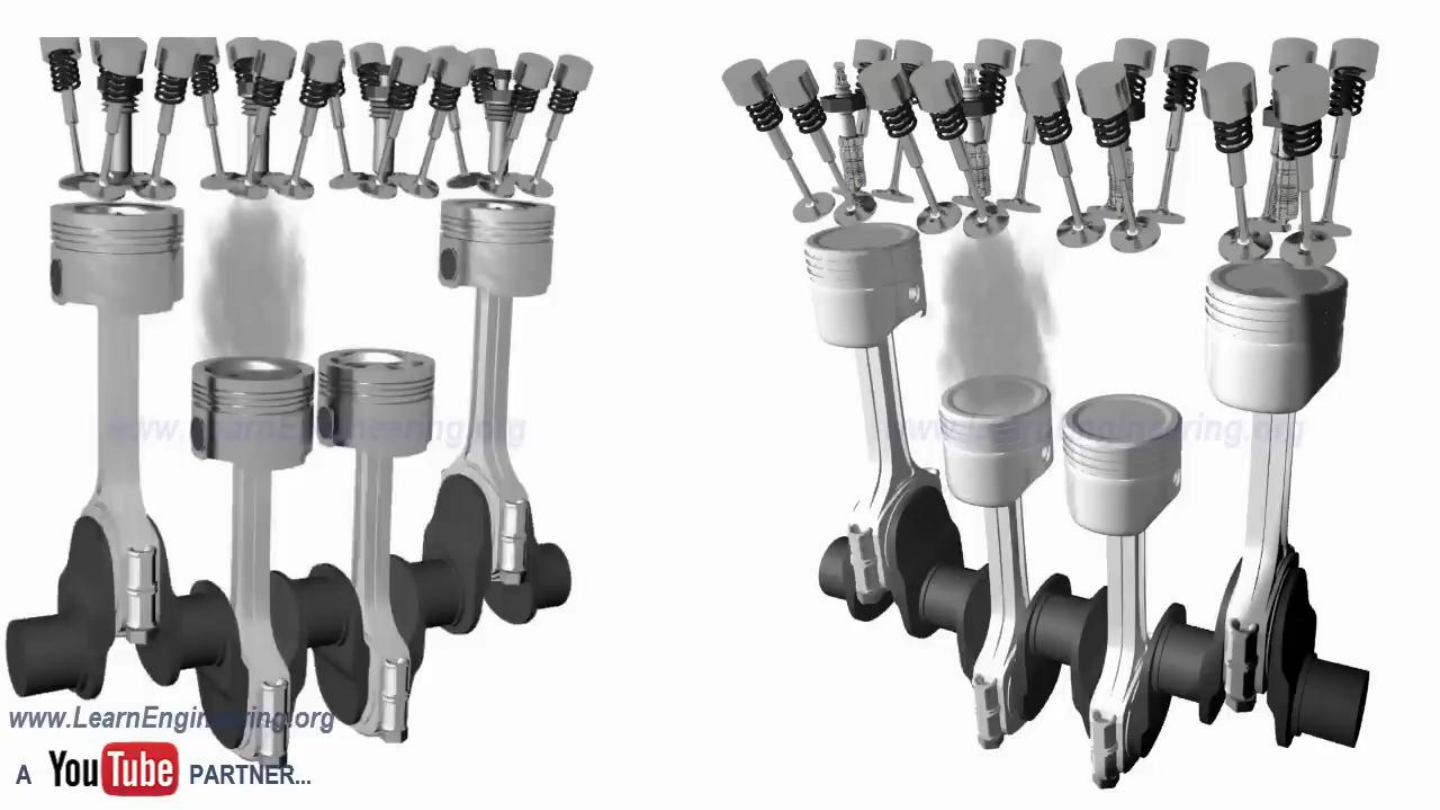
viii. Maintenance cost higher

ix. Higher thermal efficiency (40%)

x. Engines are typically slow moving

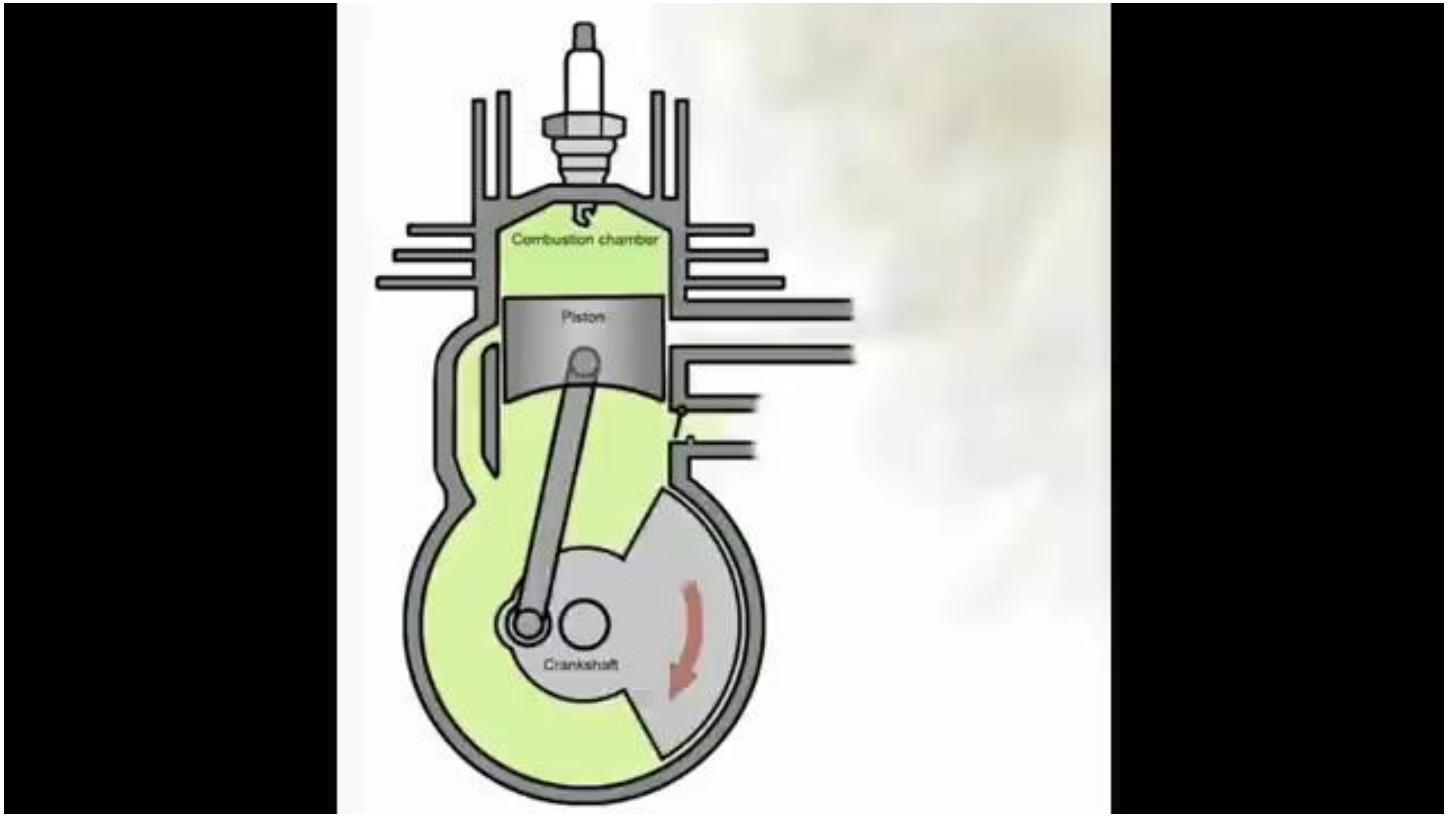
xi. Used in heavy duty vehicles such as buses, trucks etc.

SI vs CI



https://www.youtube.com/watch?v=bZUoLo5t7kg

2-stroke SI (Petrol) engine operation



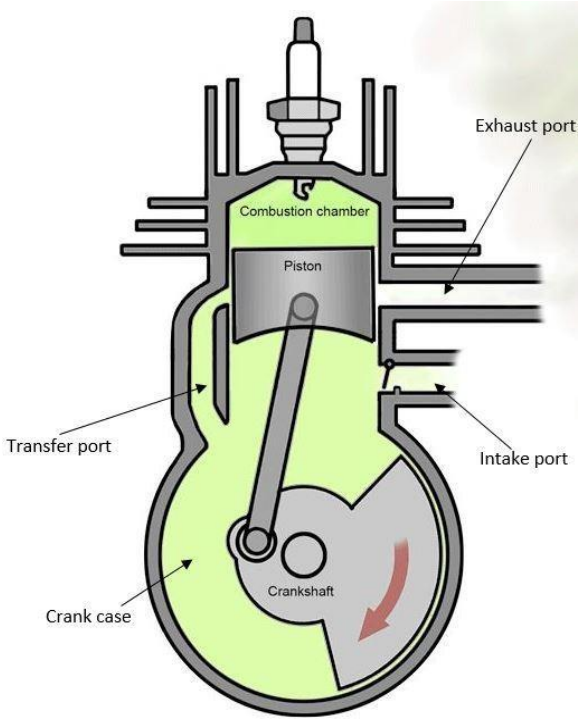
https://www.youtube.com/watch?v=xNLE8G3pC0k

2-stroke SI (Petrol) engine operation

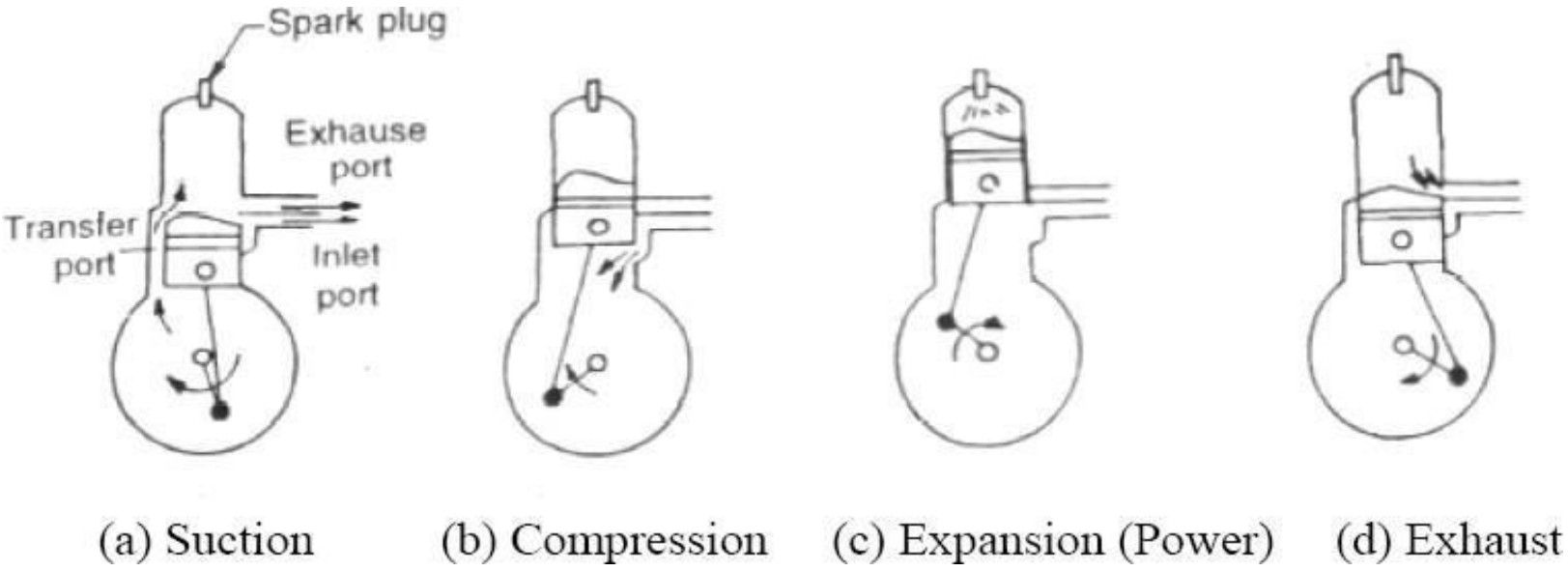
In Brief:

(a) and (b): Up-stroke of the piston : Suction and Compression.

(c) and (d) : Down stroke of the piston : Expansion and Exhaust.



2-stroke SI (Petrol) engine operation



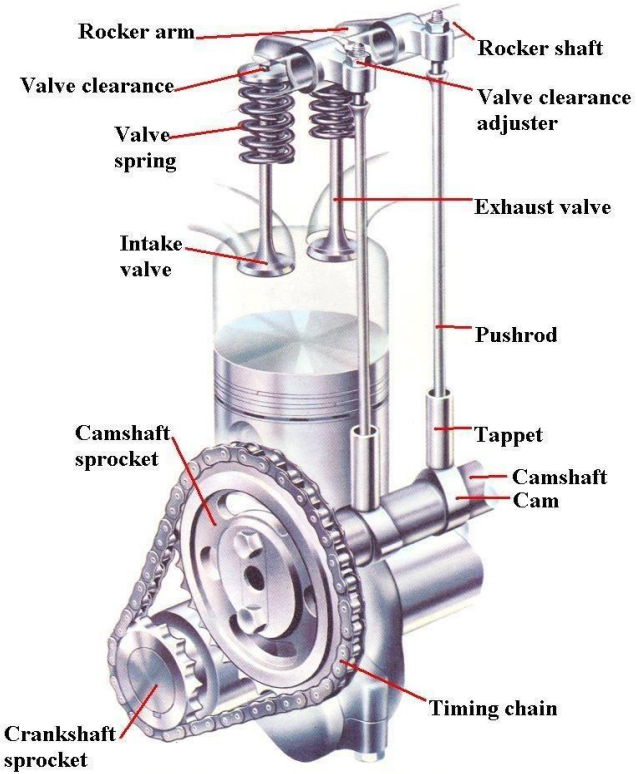
(a) Suction (b) Compression (c) Expansion (Power) (d) Exhaust

Comparison of 2-stroke and 4-stroke Engines

4-stroke Engine	2-stroke Engine
1. The intake, compression, combustion and exhaust occur in two upward and two downward strokes of the piston.	1. All four events are accomplished in one downward stroke, and one upward stroke.
2. Needs complicated valve train arrangement for intake and exhaust strokes.	2. Intake and exhaust are both integrated into the compression and combustion movement of the piston, eliminating the need for valves.
3. Outputs power once in every two revolutions of the crankshaft.	3. The engine delivers power on every revolution.
4. The engine is heavier for the same power rating, i.e., low power to weight ratio.	4. Higher power-to-weight ratio because it is much lighter.
5. More expensive than the 2-stroke engines.	5. Less expensive because of its simpler design.
6. It has limited orientation if oil is to be retained in the sump.	6. It can be operated in any orientation because it lacks the oil sump
7. More fuel efficient, less noisy, less polluting and longer lifespan.	7. Less fuel-efficient because of the simpler design, resulting in poorer mileage than a four stroke engine.
8. Less noisy.	8. Twice as much noisy.
9. Less polluting.	9. Very much polluting.
10. Usually lasts longer.	10. Does not last very long.

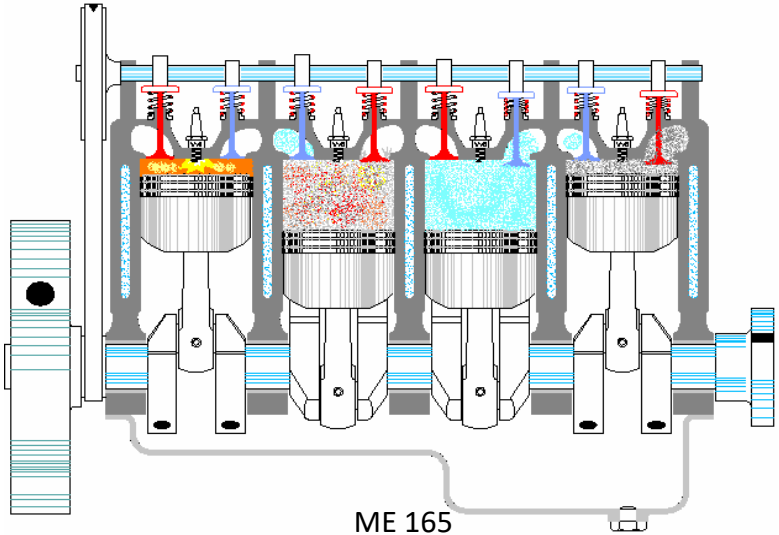
IC Engine: Cam and Camshaft

- Cam: Mechanical component used to convert rotary motion into reciprocating motion
- Cams are fitted in a camshaft
- Camshaft is driven by crankshaft by chain-sprockets or timing gears
- **1** cam required for each valve
- Camshafts rotate at half the speed of the crankshaft
- Total engine rotation: 720°
- IVO : 0°to 180°
- EVO: 540°to 720°



IC Engine: Firing Order

- Firing order: Inline four cylinder 1-4-3-2
- Firing order in a multi-cylinder engine is arranged so that the torsional moment is even and the load is uniformly distributed on longitudinal direction of the crankshaft. An even firing order will increase the balance of engine. Successive combustion in the cylinders that standing side by side should be avoided so that the force transmitted to the crankshaft does not become one-sided.



Problem 1

A six-cylinder two-stroke engine with a compression ratio r = 9 produces a torque of 1100 Nm at a speed of 2100 rpm. It has a bore b of 123 mm and a stroke s of 127 mm.

a) What is the displacement volume and the clearance volume of a cylinder?

b) mean piston speed

Solution:

$V_d = (\pi/4) * b^2 * L$

We know that $r = (V_d + V_c)/ V_c$

$U_p = 2NL/60$

Problem 1

A six-cylinder two-stroke engine with a compression ratio r = 9 produces a torque of 1100 Nm at a speed of 2100 rpm. It has a bore b of 123 mm and a stroke s of 127 mm.

a) What is the displacement volume and the clearance volume of a cylinder?

b) mean piston speed

Solution:

$V_d = (\pi/4) * b^2 * L$

$= 1.51 \times 10^{-3} m^3$

We know that $r = (V_d + V_c)/ V_c$

The clearance volume, $V_c = V_d /(r - 1)$

$= 1.89 \times 10^{-4} m^3$

$U_p = 2NL/60 = 2 * (2100/60) * 0.127 = 8.89$ m/s

Problem 2

A three-liter SI V6 engine that operates on a four-stroke cycle at 3600 RPM. The compression ratio is 9.5, length of the connecting rods is 16.6 cm, the engine is square (B=L) Calculate:

a) Cylinder bore
b) Stroke length
c) Average piston speed
d) Clearance volume of one cylinder

Solution:a. Given, Swept volume,
$V_s = 3 \times 10^{-3} m^3$ RPM of engine, N = 3600
The engine bore, B=? Stroke length, L =?

We know, $V_s = n \times (\pi/4 \times B^2 \times L)$
(here n is no. of cylinder)/

Problem 2

b. Since B = L, so L = 0.086 m

c. Average piston speed Sp =?

We know, Sp = 2NL
= 2×3600×0.086 m
= 2×(3600/60)×0.086 m
= 10.32 m/s

d. Clearance volume of one cylinder: the clearance volume for one cylinder,

We know that $r = (V_d + V_c)/ V_c$

The clearance volume, $V_c = V_d/(r - 1) = 352.941\ cm^3$

$V_C = 352.941/6\ cm^3 = 58.82\ cm^3 \approx 59\ cm^3$

Acknowledgement

- Slide Courtesy:
- Dr. Aman Uddin, Assistant Professor, Department of Mechanical Engineering, BUET
- Saif Al-Afsan Shamim, Assistant Professor, Department of Mechanical Engineering, BUET