ME 410 Day 2

Topics

- Review of General Concepts
- Geometry of IC engines: bore, stroke, displaced volume, clearance volume, compression ratio
- Conversation: What does octane number mean?

1. Review of General Concepts

For each engine type, pick the most typical application.

Four-stroke, spark ignition.

1. Heavy duty truck
2. Passenger car
3. Model airplane engine
4. Large power generator
5. Locomotive

Four-stroke, compression ignition

1. Outboard motor for boat
2. Propeller-driven aircraft
3. Passenger car
4. Lawnmower
5. Tractor for 18-wheeler

Two-stroke, spark ignition

1. Passenger car
2. Propeller-driven WWII fighter
3. Passenger car
4. Weed trimmer
5. Locomotive

Two-stroke, compression ignition

1. Locomotive engine
2. Weed trimmer
3. Passenger car
4. Model Aircraft
5. Heavy duty truck

Which has fewer moving parts? Two-stroke or Four-stroke?

The majority of engines operate on a 4-stroke operating cycle. Name the strokes and explain what happens in each.

1. -

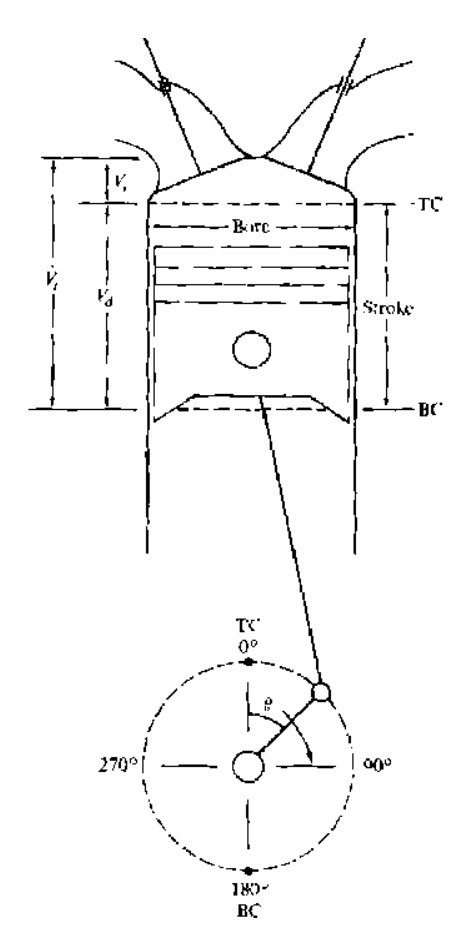
2. -

3. -

4. -

What do the piston rings do?

2. Geometrical Properties of Reciprocating Engines
(This figure is borrowed from our text by Heywood.)

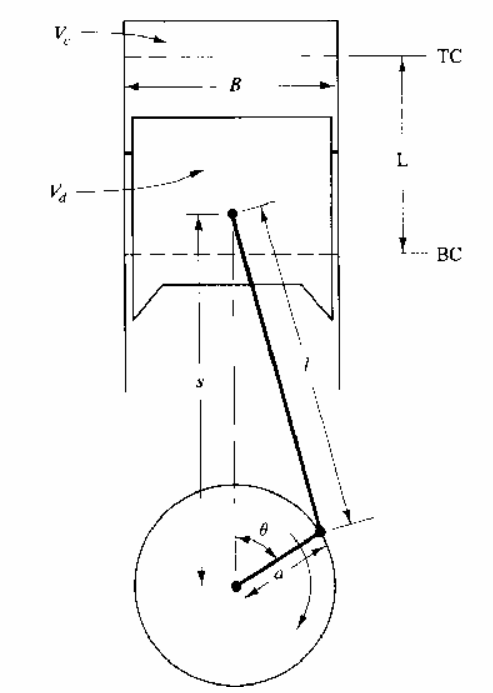


Note the following symbols and abbreviations:

- TC - piston is at top of cylinder
- BC - piston is at bottom of cylinder
- The stroke is the distance piston moves between BC and TC
- Bore is diameter of cylinder
- V_c is clearance volume. Volume at TC
- V_d is volume swept out between BC and TC

Multiplying the V_d by number of cylinders gives the engine's displaced volume.

For more geometry, see the following figure from the start of Ch. 2.



We come up with the following: (B = bore; L = Stroke)

$$V_d = \frac{\pi B^2}{4} L$$

Also B/L =0.8 to 1.2 for small to medium size engines. Can be as low as 0.5 for large CI engines.

The compression ratio is given the symbol r_c.

$$r_c = \frac{\text{maximum volume}}{\text{minimum volume}} = \frac{V_d + V_c}{V_c}$$

Typical values of r_c for SI engines: 8 to 12.
Typical values of r_c for CI engines: 12 to 24

Let a = crank radius. Please note that

$$L = 2a$$

Define mean piston speed.

$$\overline{S}_p = 2LN$$

(8 - 15 m/s in most engines)

where N is rotation speed in rev/time. This is not the same as instantaneous piston velocity, which varies over the stroke.

The relationship of instantaneous velocity of piston to mean piston speed

```
> restart;
> s1 := a*cos(theta(t)) + sqrt( (R*a)^2-
(a*sin(theta(t)))^2);
```

$$s1 := a\cos(\theta(t)) + \sqrt{R^2 a^2 - a^2 \sin(\theta(t))^2}$$

```
> v1 := diff(s1,t);
```

$$v1 := -a\sin(\theta(t))\left(\frac{\partial}{\partial t}\theta(t)\right) - \frac{a^2 \sin(\theta(t))\cos(\theta(t))\left(\frac{\partial}{\partial t}\theta(t)\right)}{\sqrt{R^2 a^2 - a^2 \sin(\theta(t))^2}}$$

```
> Sp:=subs( diff(theta(t),t) = omega,v1);
```

$$Sp := -a\sin(\theta(t))\,\omega - \frac{a^2 \sin(\theta(t))\cos(\theta(t))\,\omega}{\sqrt{R^2 a^2 - a^2 \sin(\theta(t))^2}}$$

```
> Sbarp := 2*(2*a)*omega/(2*Pi);
```

$$Sbarp := 2\,\frac{a\,\omega}{\pi}$$

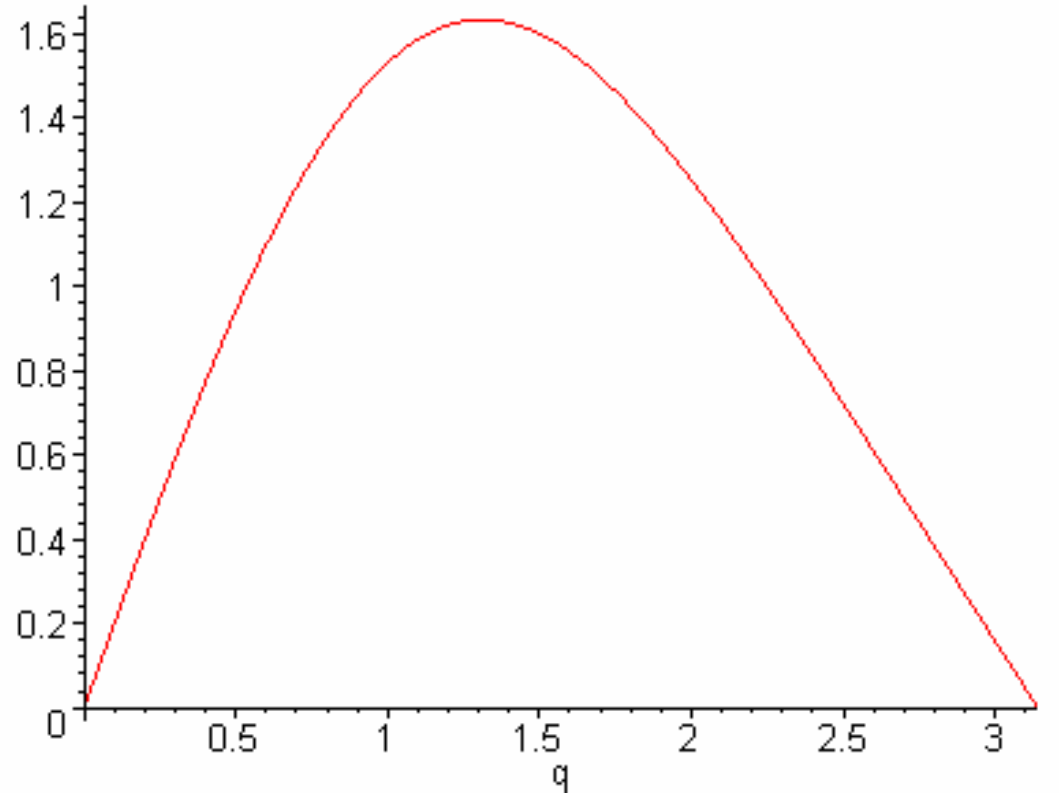
```
> ratio := Sp/Sbarp;
```

$$ratio := \frac{1}{2}\,\frac{\left(-a\sin(\theta(t))\,\omega - \frac{a^2 \sin(\theta(t))\cos(\theta(t))\,\omega}{\sqrt{R^2 a^2 - a^2 \sin(\theta(t))^2}}\right)\pi}{a\,\omega}$$

```
> ratio1 := -
evalf(subs(R=3.5,a=1,omega=1,theta(t)=q,ratio));
```

$$ratio1 := 1.570796327\sin(q) + \frac{1.570796327\sin(q)\cos(q)}{\sqrt{12.25 - 1.\sin(q)^2}}$$

```
> plot(ratio1,q=0..Pi);
```



>

This is supposed to duplicate Fig. 2-2. R = l/a = 3.5

$$\frac{\overline{S_p}}{S_p} = \frac{\pi}{2}\sin(\theta)\left[1+\frac{\cos(\theta)}{\sqrt{R^2-\sin(\theta)^2}}\right]$$

Conversation: Meaning of Numbers on Fuel Pump

What is “knock?” Associate with compression ratio. Pre-ignition of the “end gas.”
Numbers are essentially a measure of the fuel’s resistance to knock.
Isooctane and n-heptane. Chem formulas.
A standard engine is tested with various mixtures. (88=88% isooctane and 12% n-heptane.)
Your fuel has the same knock resistance as the mixture whose number is given.
Two tests: Research Octane Number and Motor Octane Number
Regular: RON=91 & MON=83.
Antiknock index = (RON+MON)/2
What about octane numbers over 100%? There is an additive, most common being tetraethyl lead.