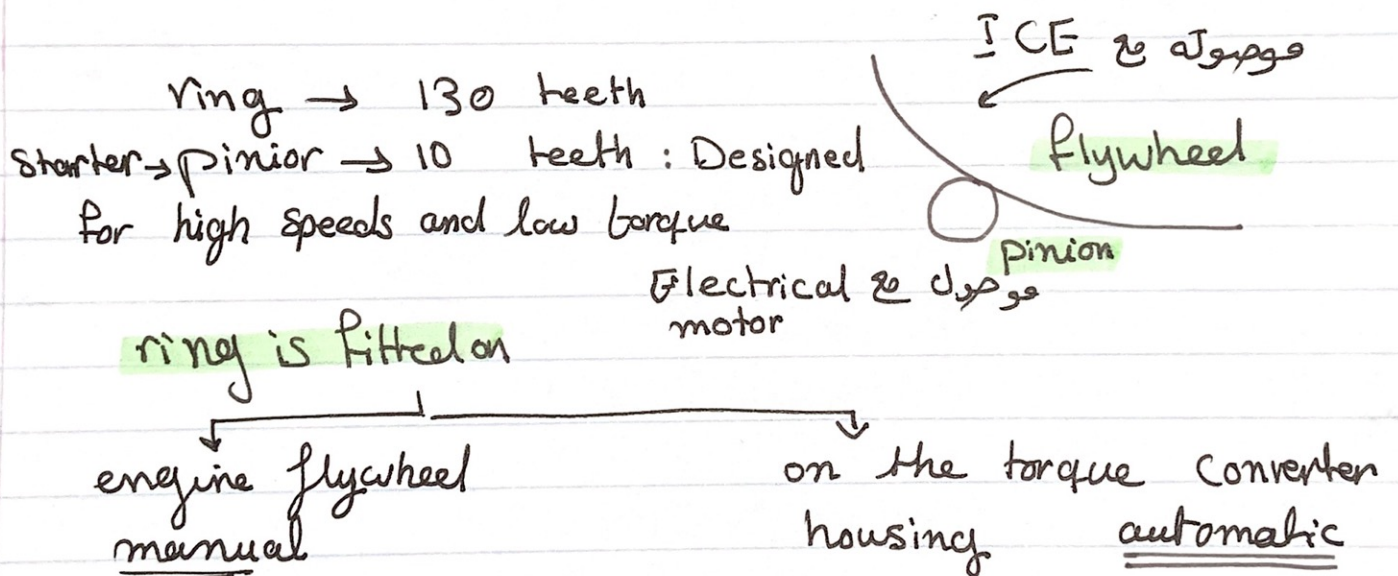


Chapter 3: Engine Starting System

Starter: It cranks the internal combustion engine at a minimum speed before supply sufficient energy to the internal comb. engine to cover:-

- 1- Compression
- 2- Gas Exchange
- 3- Friction → bearing surface are not adequately lubricated

The Torque From starter is transferred by:-
 pinion & a ring gear and (sometimes) V-belt, toothed belt or chain → to crankshaft



ring → 130 teeth
 starter → pinion → 10 teeth : Designed for high speeds and low torque

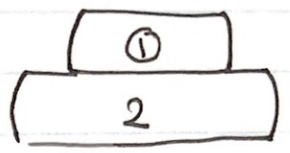
Pinion 1 N.m → 13 N.m ring
 10 rpm → $\frac{10}{13}$ rpm

Working Principle

We have two motors: (electrical motors)

1. The one up controls whether the pinion connects to the fly wheel or not

2. Second one down transmits power to engine



► Chamfer on pinion → to reduce noise

Starter Structure

In slide 7

1, 2, 3: جزئي

4-11: جزئي

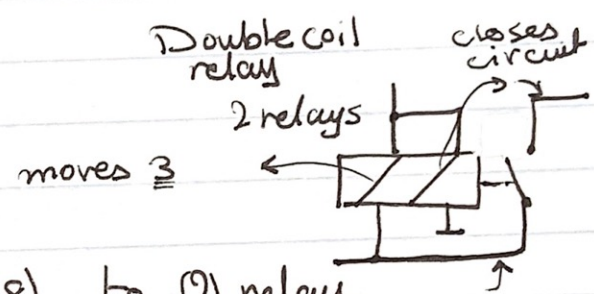
7, 12: mesh

5: lever moves the shaft and Pinion

10: handles meshing process

3: pushes 5

• Number of turns of 9 → Divide By 13 = N. of 12



How?

1 is closed, I from battery (8) to (2) relay relay 2 moves 3 (and*)

* allowing I from (8) to pass to (4) Stator and lastly to (9) Rotor

Relay (electromagnetic switching): activated by signal.

• I small → Electro magnet → Armature up and circuit is closed → I high

Engagement relay structure

2, 3 windings → effective for thermal stress capacity & magnetic force that is achieved

1 Armature connected to lever

9 switch shaft → 8, 6 connect and circuit is closed (*)

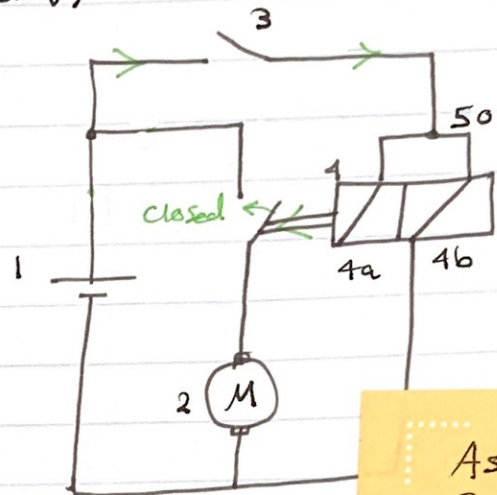
- When switch is opened 4 is back, 1 is back, circuit is open and ICF is working

Functions of engagement relay:-

- 1- advances the pinion
- 2- closes the contact bridge (completes starter's primary electric circuit)

Slide 41

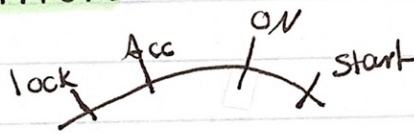
- When 3 is closed I moves from 1



Ask about Slide 41

Ignition positions

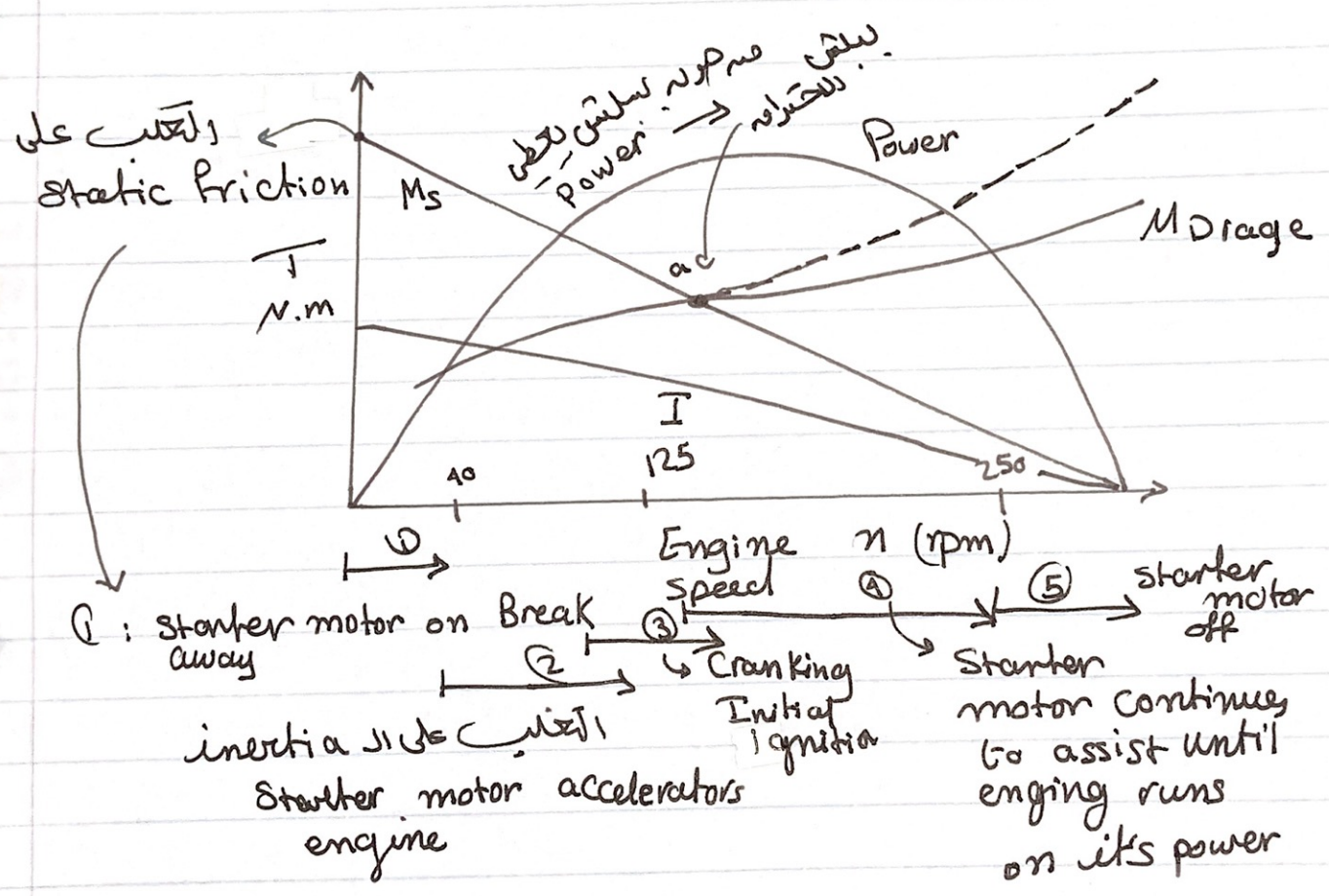
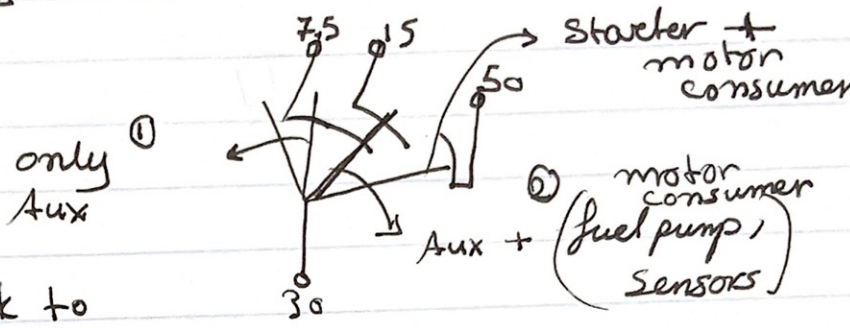
- lock/off: everything is closed



- Acc / Accessory: it allows to use accessories of the car
- ON / Run: fuel pump, diesel heater — Power supply for ignition & engine
- Start: switch on the electric starter when it's released starter goes back to prev. position

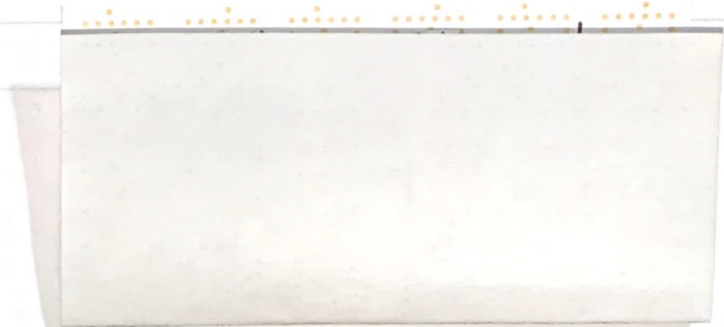
- Term 50: Voltage for starter
- Term 30: connection for power supply (Battery)
- Term 75: Auxilliary (batter consumer)
- Term 15: Ignition & motor consumer

- That's why when we turn the car the radio turns off
- The key goes back to 15



- Starter motor on Break away
- inertia Starter motor accelerators engine
- Cranking Initial Ignition
- Starter motor continues to assist until engine runs on its power
- starter motor off

- Ignition starts after ① & ②
- 250 → 300 : motor can depend on itself and T=0
- Combustion starts at point a



- Warm engine takes two revolutions of the crankshaft to start. Cold engine need more time
- engine management system uses sensors to detect the position of the crankshaft
- starters are up to an output of 2.5KW, $V=12$
- Gasoline engine : 7 liters
- Diesel engine : 3 liters

Note: needs higher power starter even if capacity is the same (liters) due to ① higher C.R
 ② Diesel F.S is higher

Gasoline = 8:1 - 12:1
 ↳ Diesel
 14:1 - 25:1

Automatic Starting System

- Safety
- Quality
- low noise levels

Engine
Start
Stop

Differs from conventional by:-

- A ballast relay
- A control unit (controls starting sequence)

When you click it, it sends a message to the control unit → performs series of checks

Checks

- 1- Is the driver authorized (theft deterrence)
- 2- " " engine at a standstill? $\delta \delta \delta \delta \delta$
- 3- Battery sufficient, temperature of engine?
- 4- Is the selector lever is neutral (D, R) (the car won't work)
 $went (P, N) to work$

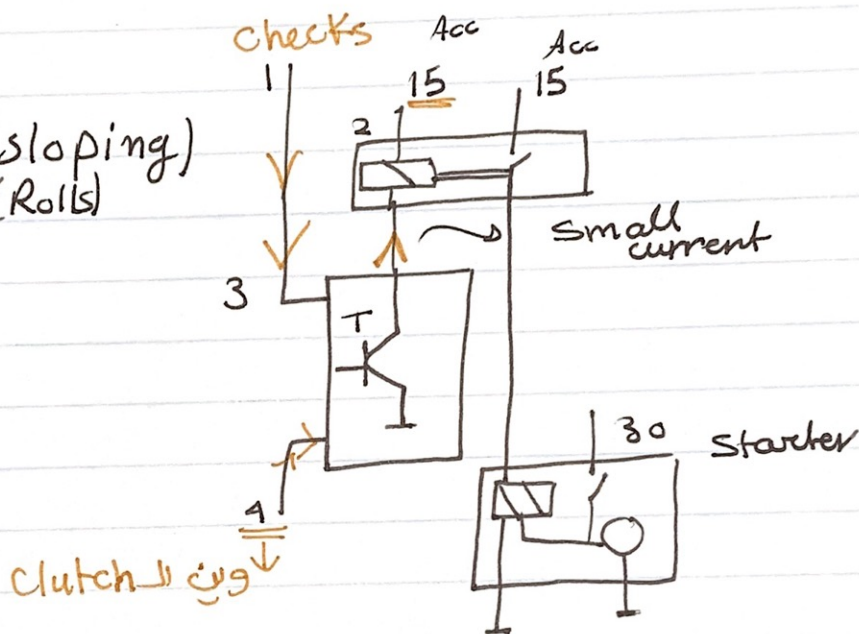
For manually transmission clutch should be disengaged or no gear selected

Forces the car needs to beat (Driving Resistance)

- 1- Aerodynamics
- 2- Acceleration
- 3- Gradeability (sloping)
- 4- Chassis losses (Rolls)

15: Acc

$$n_{eng} = f(T_{eng})$$

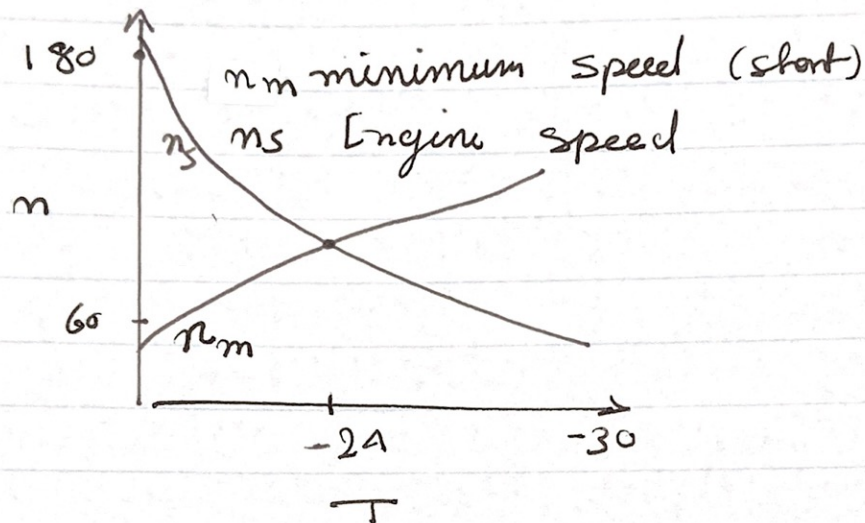


Design of starter

- 1- starting temp (lowest engine & battery temp)
- 2- cranking resistance of the engine : torque at the crank shaft including T_{ux}
- 3- minimum engine speed $\rightarrow 52$
- 4- conversion ration (Starter & crank shaft)
- 5- nominal voltage of starting system
- 6- characteristics of the starter battery
- 7- Resistance between battery & starter & contact resistance

- 8- Speed characteristics of the starter
 9- Maximum voltage Drop

Back to ①



Viscosity of the engine lubricant \rightarrow engine temp

$$T \downarrow \rightarrow n_m \uparrow$$

$$T \uparrow \rightarrow n_s \uparrow$$

Back to ②

The design depends on:-

- 1- Number of cycles
- 2- Ratio of stroke to bore : Distance that cylinder moves
- 3- C.R
- 4- Nature of their bearings
- 5- Drag From clutch
- 6- Mass of the Moving engine components
- 7- Transmission & auxiliary drive systems