

Automobile Engineering (315372)

MSBTE K-Scheme · Model Question Paper — Set C · Model Answers

Answers are written in MSBTE model-answer style. In the exam, answer only the required number of sub-questions (any FIVE / THREE / TWO).

Q.1

a) Automobile; functions of two major components.

2 M

Automobile: a self-propelled vehicle that carries its own power source and is used to transport passengers and goods on road (auto = self, mobile = movable).

Functions (any two): *Chassis frame* — supports and holds all components and body. *Engine* — produces power. *Transmission system* — transmits engine power to the driving wheels with required torque and speed. *Brakes* — slow down and stop the vehicle. *Steering* — controls the direction of motion. *Suspension* — absorbs road shocks.

(Definition 1 M, functions 1 M)

b) Requirements of a good clutch.

2 M

- It should transmit maximum engine torque without slipping (adequate torque capacity).
- Engagement should be gradual and smooth, without jerk.
- It should disengage quickly and completely (free disengagement).
- It should dissipate heat well; friction linings should have high μ and long life.
- Driven parts should have low inertia (easy gear change); operation should need small pedal effort; it should damp vibrations.

(Any four, $\frac{1}{2}$ M each)

c) Functions of propeller shaft.

2 M

- To transmit torque from the gear box output shaft to the differential (final drive) in a front-engine rear-wheel-drive vehicle.
- To accommodate variations in the angle between gear box and rear axle (through universal joints).
- To accommodate changes in length between gear box and rear axle when the axle moves up and down on springs (through slip joint).

(Any two, 1 M each)

d) Camber and king pin inclination.

2 M

i) Camber: The inclination of the wheel centre line from the vertical, seen from the front of the vehicle. Top of wheel outward = positive camber.

ii) King pin inclination: The inclination of the king pin (steering axis) centre line from the vertical, seen from the front, with its top tilted inward towards the vehicle centre (about 7° – 8°).

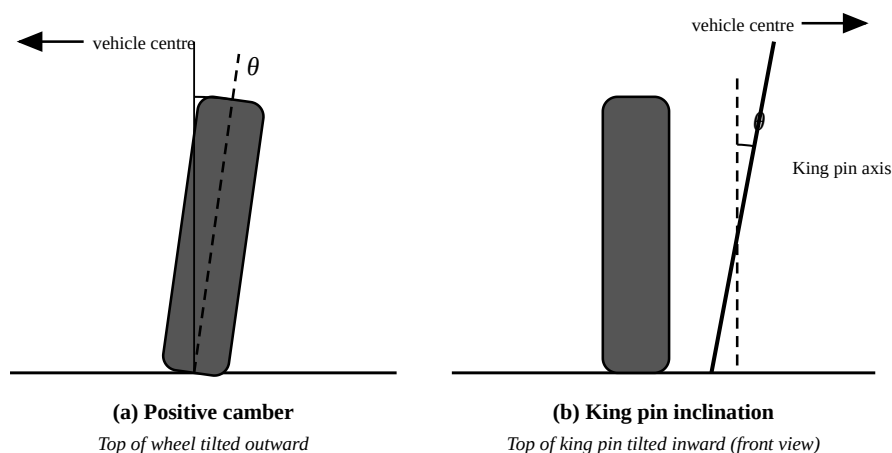


Fig. Camber and king pin inclination

(1 M each)

e) Tube type vs tubeless tyre.

2 M

Tube type	Tubeless
Separate inner tube holds the air.	Air is held by the tyre itself with an air-tight inner liner and rim.
Sudden deflation on puncture.	Slow deflation — safer.
Tyre must be removed to repair tube.	Repaired by plug without removing tyre.
Heavier, runs hotter.	Lighter, runs cooler.

(Any two, 1 M each)

f) Functions of starting system.

2 M

- To crank (rotate) the engine at a minimum speed (about 100–200 rpm for SI engines) so that it can start on its own.
- To convert electrical energy of the battery into mechanical energy using the starter motor.
- To engage the starter pinion with the flywheel ring gear during cranking and disengage it after the engine starts (Bendix drive / solenoid with over-running clutch).

(Any two, 1 M each)

g) Components mounted on chassis.

2 M

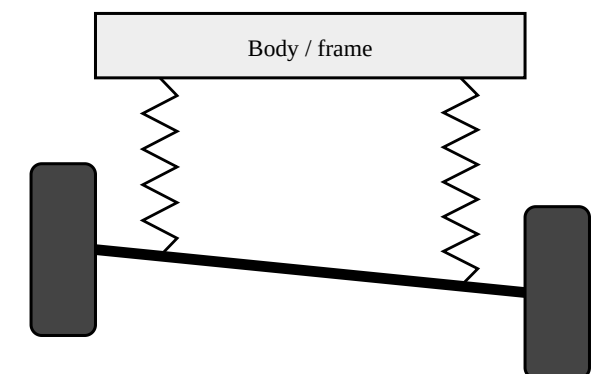
Engine, clutch and gear box, propeller shaft, differential and rear axle, front axle, steering system, suspension system (springs and shock absorbers), wheels and tyres, brakes, fuel tank, radiator, silencer and exhaust pipe, battery.

(Any four, ½ M each)

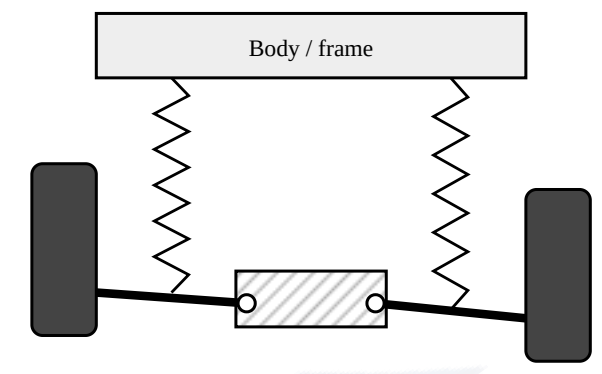
Q.2

a) Rigid axle vs independent suspension.

4 M



(a) Rigid axle: one wheel lifts → other wheel also tilts



(b) Independent: each wheel moves without affecting the other

Fig. (a) Rigid axle suspension and (b) Independent suspension — front view

Point	Rigid axle suspension	Independent suspension
Wheel movement	Both wheels on one beam — bump on one wheel affects the other.	Each wheel moves independently.
Ride comfort	Poorer; more body tilting and shimmy.	Better ride and road holding.
Unsprung weight	More (whole axle is unsprung).	Less.
Construction and cost	Simple, robust and cheap.	Complicated and costly; more joints.
Wheel alignment	Camber does not change with load.	Camber/track may change with wheel movement.
Application	Trucks, buses, rear of some cars.	Front of almost all cars; rear of many cars.

(Any four points, 1 M each)

b) Diaphragm spring clutch.

4 M

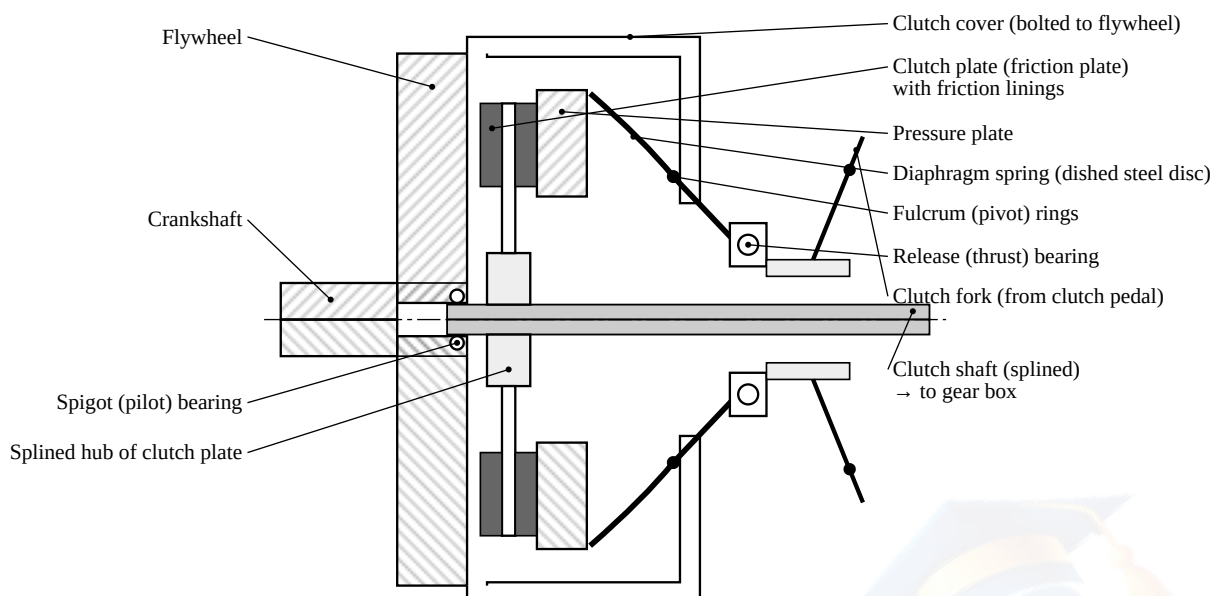


Fig. Single plate clutch with diaphragm spring (engaged position)

Construction: It is a single plate clutch in which the coil springs and release levers are replaced by a single **diaphragm spring** — a dished (conical) steel disc with radial slots forming fingers. The spring is held in the clutch cover by two fulcrum (pivot) rings. Its outer edge presses on the pressure plate; its inner fingers are acted upon by the release bearing.

Working: *Engaged* — the dished spring presses the pressure plate, gripping the clutch plate between flywheel and pressure plate; torque passes to the clutch shaft. *Disengaged* — when the pedal is pressed, the release bearing pushes the fingers inward; the spring pivots on the fulcrum rings and its outer edge moves back (like an oil-can lid), relieving the pressure plate, so the clutch plate becomes free.

Advantages: fewer parts, compact; uniform pressure; pedal effort decreases as the lining wears; not affected by centrifugal force at high speed.

(Sketch 2 M, explanation 2 M)

c) Disc brake vs drum brake.

4 M

Disc brake	Drum brake
Friction pads squeeze a rotating disc.	Brake shoes expand against inner surface of a rotating drum.
Better heat dissipation; less fade.	Poor cooling; more fade on continuous braking.
Not self-energising; higher pedal force (servo needed).	Self-energising action reduces pedal force.
Self-cleaning; less affected by water.	Water and dust remain inside the drum.
Easy inspection and pad replacement.	Drum removal needed for inspection.
Costlier; used on front wheels.	Cheaper; used on rear wheels and heavy vehicles.

(Any four, 1 M each)

d) Tyre designation 205/55 R16 91V; numerical.

4 M

Marking	Meaning
205	Section width of tyre = 205 mm
55	Aspect ratio = (section height / section width) $\times$ 100 = 55 %
R	Radial ply construction
16	Rim diameter = 16 inch
91	Load index — maximum load per tyre = 615 kg
V	Speed rating — maximum speed 240 km/h

Sidewall (section) height $h = 205 \times 55 / 100 = 112.75 \text{ mm}$

Rim diameter = $16 \times 25.4 = 406.4 \text{ mm}$

Overall diameter $D = \text{rim diameter} + 2h = 406.4 + 2 \times 112.75 = 631.9 \text{ mm}$

(Rolling circumference $\approx \pi D = 1985.2 \text{ mm}$, i.e. about 503.7 revolutions per km, neglecting tyre deflection.)

(Meaning 2 M, calculation 2 M)

Q.3

a) Conventional frame vs unitized construction.

4 M

Point	Conventional frame	Unitized (frameless) construction
Structure	Separate frame (side + cross members) carries all loads; body bolted on it.	No separate frame; welded body shell carries all loads.
Weight	Heavier.	Lighter — better fuel economy.
Height / C.G.	Higher floor and centre of gravity.	Lower floor and C.G. — better stability.
Strength / stiffness	Very strong in bending; lower torsional stiffness.	High torsional stiffness for its weight.
Repair after accident	Easy to repair / straighten.	Difficult and costly to repair.
Noise and vibration	Body isolated by rubber mounts — quieter.	More noise transmitted; needs sound-proofing.
Application	Trucks, buses, SUVs.	Most passenger cars.

(Any four, 1 M each)

b) Synchromesh gear box.

4 M

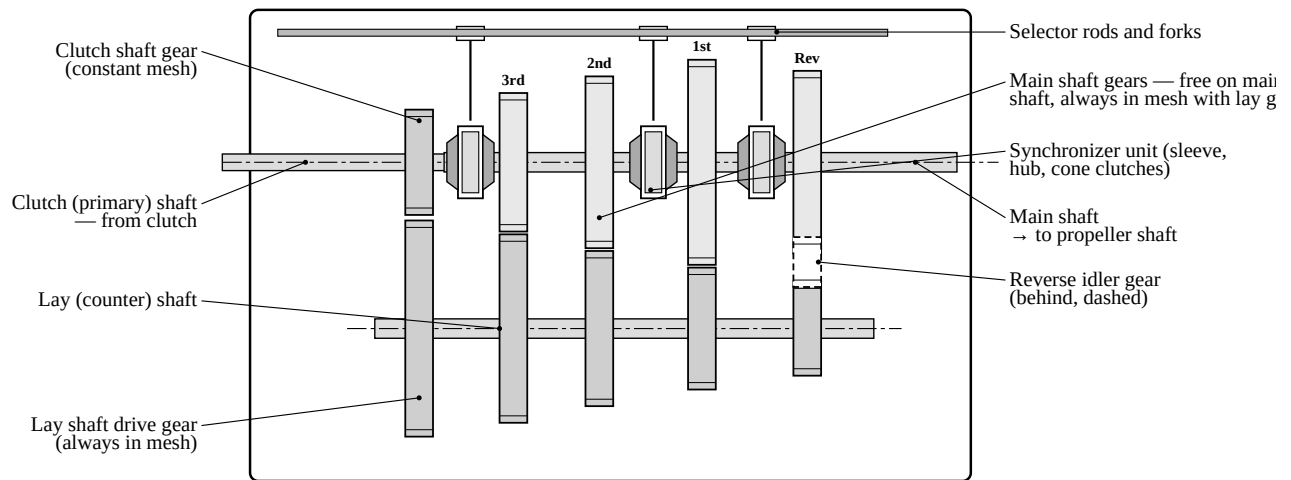


Fig. Synchromesh gear box (4 forward + reverse) — schematic

Construction: It is a constant mesh gear box in which the dog clutches are replaced by **synchronizer units**. The main shaft gears are always in mesh with lay shaft gears and are free on the main shaft. Each synchronizer has a hub splined to the main shaft, an outer sleeve with internal teeth, and a **cone clutch** (internal cone/baulk ring on the synchronizer and external cone on the gear).

Working: When the driver moves the gear lever, the sleeve first pushes the synchronizer cone against the cone on the gear. The friction between the cones brings the gear and the main shaft to the **same speed** (synchronisation). Only then the sleeve slides further and its teeth engage the dog teeth on the gear, locking the gear to the main shaft. Thus gears are engaged without clash and without double declutching. Used in all modern cars (usually for all forward gears).

(Sketch 2 M, explanation 2 M)

c) Recirculating ball steering gear box.

4 M

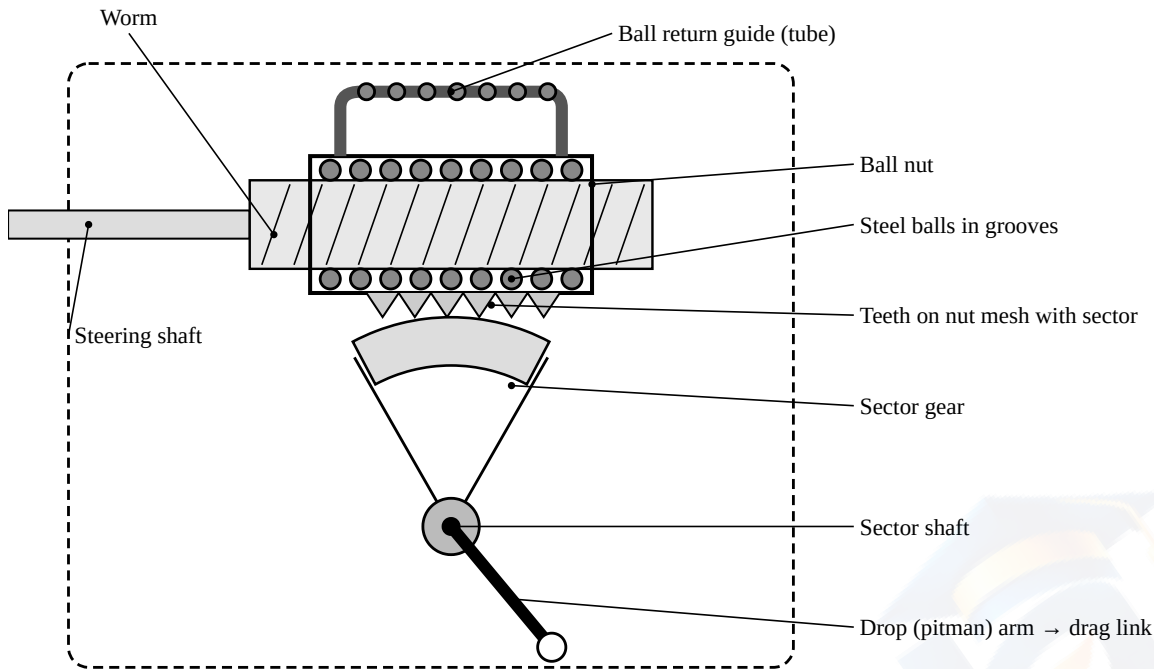


Fig. Recirculating ball type steering gear box

Construction: The lower end of the steering shaft has a **worm** with a helical groove. A **ball nut** fits over the worm; the grooves of worm and nut together form a helical passage filled with **steel balls**. Ball return guides (tubes) connect the two ends of the passage so that the balls circulate continuously. Teeth on the outside of the ball nut mesh with a **sector gear** on the sector (rocker) shaft, which carries the drop (pitman) arm.

Working: When the steering wheel is turned, the worm rotates; the balls roll in the grooves and move the nut axially along the worm (the nut cannot rotate). The nut teeth turn the sector gear, which swings the drop arm and moves the drag link / linkage to steer the wheels. Because there is rolling contact (balls) instead of sliding, friction is very low, steering is light and wear is small. Used in heavy vehicles, trucks, jeeps and SUVs.

(Sketch 2 M, explanation 2 M)

d) Cross ply vs radial ply tyres.

4 M

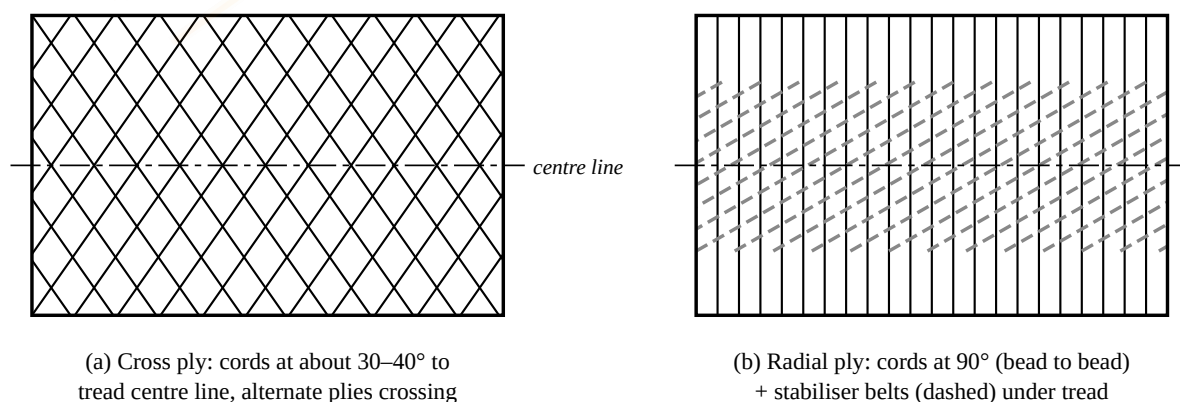


Fig. Cord arrangement: (a) cross (bias) ply and (b) radial ply tyre

Cross (bias) ply	Radial ply
Ply cords run diagonally at about 30–40° to the tread centre line; alternate plies cross each other.	Ply cords run at 90° (radially, bead to bead); steel/fabric belts under the tread.
Sidewall and tread are equally stiff.	Flexible sidewall, stiff (belted) tread.
More rolling resistance and heat; higher fuel consumption.	Less rolling resistance; better fuel economy.
Tread squirms — faster wear; less grip on cornering.	Tread stays flat on road — longer life, better grip.
Softer ride at low speed; cheaper.	Harsher ride at low speed; costlier.

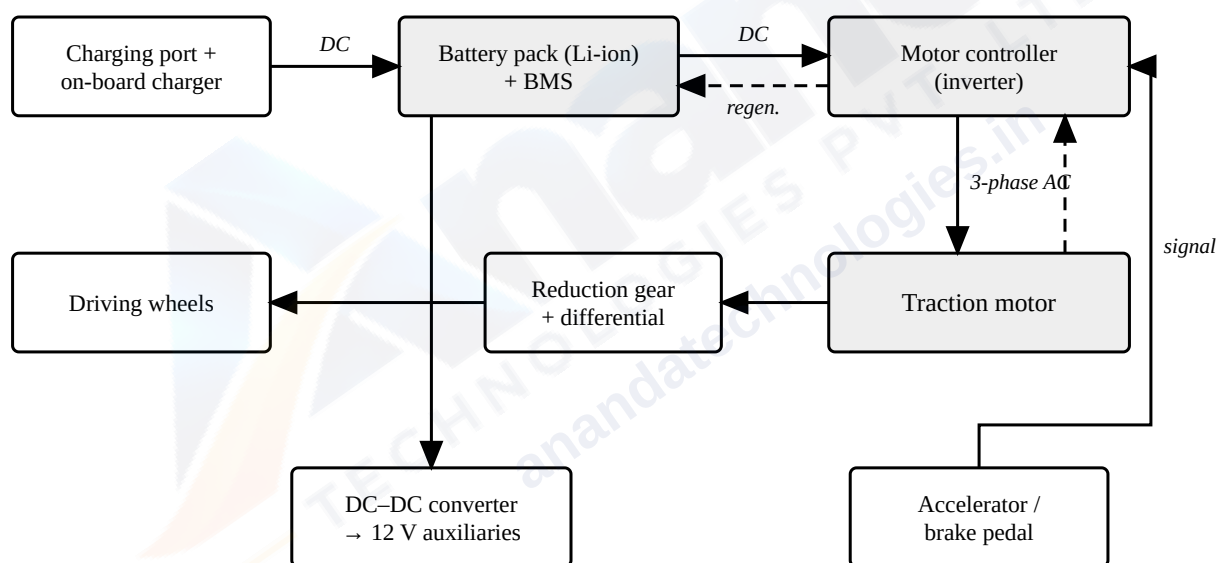
(Sketches 2 M, any four points 2 M)

Q.4

a) Need of EV; components with block diagram.

4 M

Need: zero tail-pipe emission (reduces urban air pollution and CO₂); reduces dependence on imported petroleum; high efficiency and low running cost; quiet operation; energy recovery by regenerative braking.



Dashed arrows: regenerative braking — motor works as generator and charges the battery

Fig. Layout (block diagram) of a battery electric vehicle

- **Battery pack + BMS:** stores energy; BMS protects cells.
- **Controller / inverter:** converts DC to AC and controls motor speed and torque.
- **Traction motor:** drives the wheels; generator during braking.
- **Charger and DC–DC converter:** charge the battery and supply 12 V auxiliaries.
- **Reduction gear + differential:** transmit motor torque to wheels.

(Need 1 M, block diagram 2 M, functions 1 M)

b) Necessity of shock absorber; telescopic shock absorber sketch.

4 M

Necessity: When the spring absorbs a road shock, it keeps oscillating for a long time. These oscillations make the ride uncomfortable and reduce tyre–road contact (poor braking and steering). The shock absorber damps the spring oscillations quickly by converting their energy into heat in oil, giving comfort, stability and longer life of components.

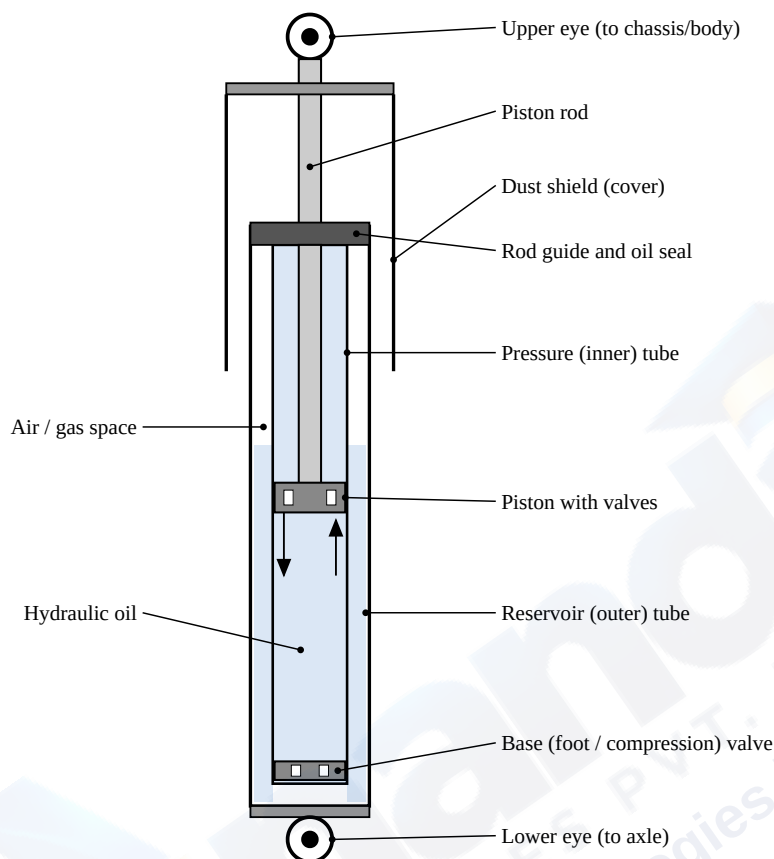


Fig. Telescopic (hydraulic, twin-tube) shock absorber

On bump the piston moves down and oil passes through piston valves and base valve; on rebound the piston moves up and oil is forced through rebound valves — the throttling of oil damps the motion.

(Necessity 1 M, labelled sketch 3 M)

c) Power steering — necessity and principle.

4 M

Necessity: In heavy vehicles and modern cars with wide low-pressure tyres and front engines, the steering effort is very high, especially while parking. A low steering ratio would need too many turns of the steering wheel. Power steering reduces driver effort, gives quick response and reduces driver fatigue; it also absorbs road shocks.

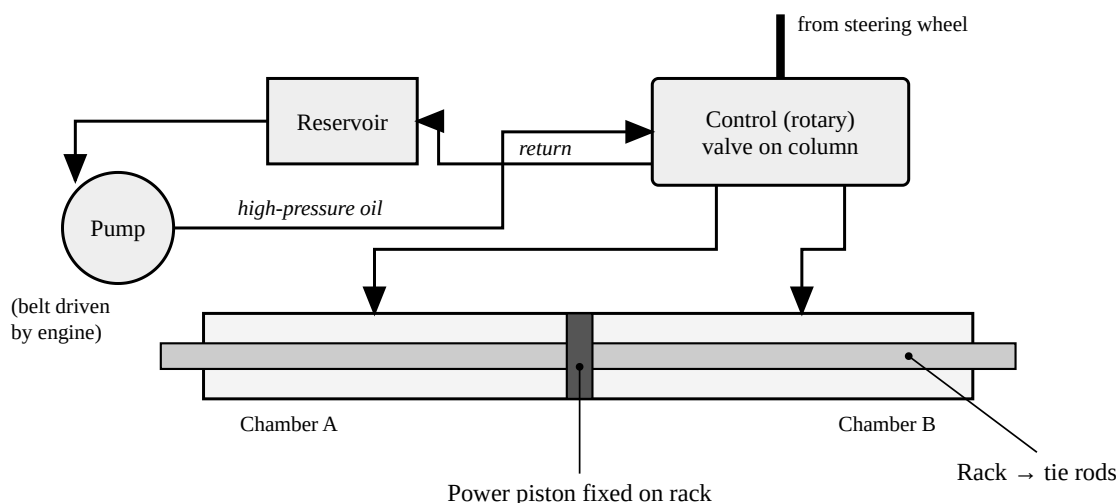


Fig. Hydraulic power steering (rack and pinion type) — schematic

Principle (hydraulic): An engine-driven pump supplies oil under pressure from a reservoir to a control (rotary) valve operated by the steering shaft. When the steering wheel is turned, the valve directs high-pressure oil to one side of the power piston (fixed on the rack) and connects the other side to return. The oil pressure pushes the piston and rack in the direction of turning, assisting the driver. When the steering wheel is held steady, the valve returns to neutral and pressure on both sides is equal. If the pump fails, the system works as manual steering. (In EPS, an electric motor gives the assistance.)

(Necessity 1 M, sketch 1½ M, principle 1½ M)

d) Wheel alignment — necessity and procedure.

4 M

Necessity: Wheel alignment means adjusting camber, caster, toe-in/toe-out and checking KPI so that wheels are set as per manufacturer's specification. Correct alignment gives easy and stable steering, self-centering, straight running without pulling, minimum tyre wear and better fuel economy. Alignment is disturbed by hitting pot holes, accidents and wear of suspension/steering parts.

Procedure (wheel aligner):

1. Place the vehicle on a level alignment ramp/turn plates; check and correct tyre pressures; check for worn ball joints, tie rod ends, bearings and suspension parts.
2. Bounce the vehicle to settle the suspension; fit the sensor heads / targets on all wheels and do rim run-out compensation.
3. Measure caster (by turning wheels through $\pm 20^\circ$), camber, KPI and toe; compare with specifications on the screen.
4. Adjust caster and camber (by shims, eccentric bolts, strut top or tie bars as per design).
5. Centre the steering wheel and lock it; adjust toe-in by turning the tie rods (equally on both sides) and tighten lock nuts.
6. Recheck all angles, print the report and road-test the vehicle for straight running.

(Necessity 1 M, procedure 3 M)

e) Electronic ignition system.

4 M

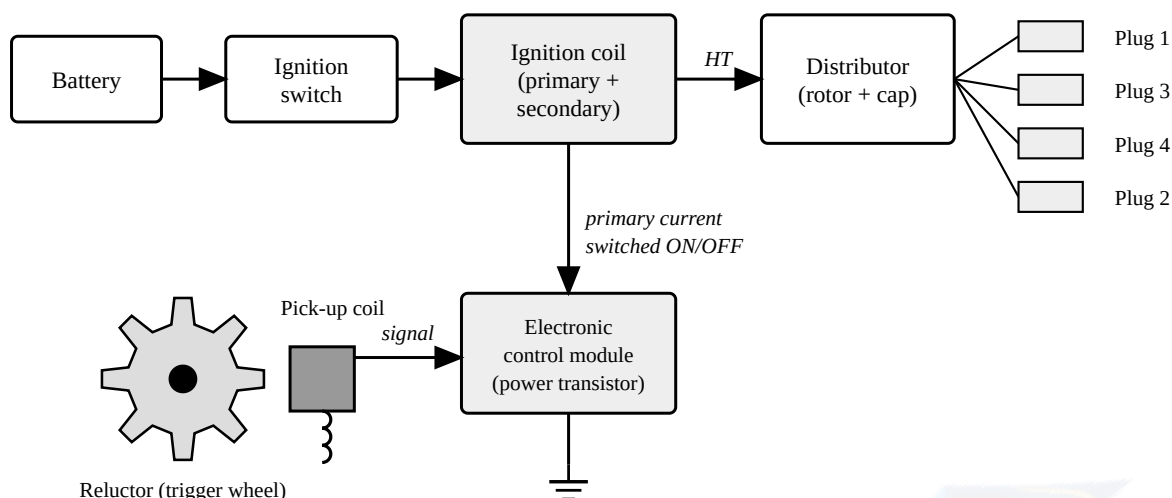


Fig. Electronic (transistorised, breakerless) ignition system

Working: In electronic (transistorised, breakerless) ignition, the contact breaker is replaced by a **pulse generator** — a reluctor (trigger wheel) with teeth equal to number of cylinders, rotating past a magnetic pick-up coil in the distributor. As each tooth passes the pick-up, a voltage pulse is generated and sent to the **electronic control module**. The module's power transistor switches the ignition coil primary current ON and OFF. When the transistor switches OFF, the primary current stops suddenly, the magnetic field collapses and a very high voltage is induced in the secondary. This is distributed to the spark plugs in firing order.

Advantages: no CB point wear or burning, accurate timing, high and constant spark energy at all speeds, less maintenance, better starting and lower emissions.

(Diagram 2 M, explanation 2 M)

Q.5

a) Differential — construction, working, numerical.

6 M

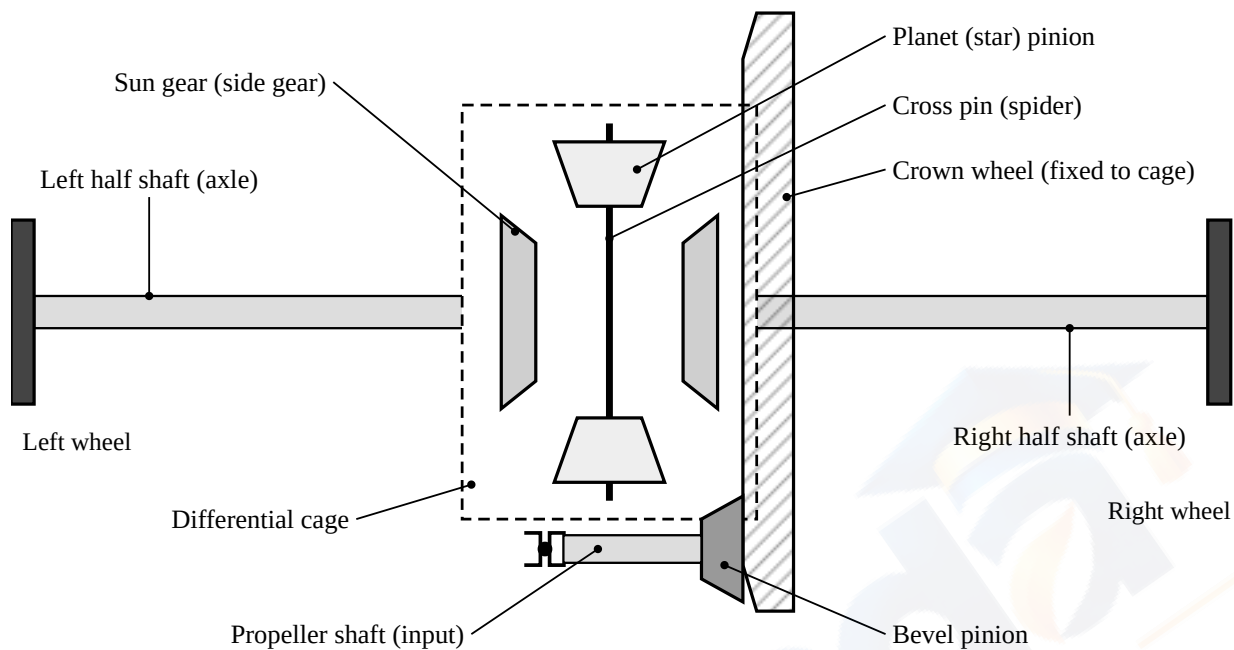


Fig. Conventional differential — plan view (schematic)

Construction: Bevel pinion (driven by propeller shaft) meshes with crown wheel bolted to the differential cage. The cage carries planet (star) pinions on a cross pin; these mesh with two sun (side) gears splined to the half shafts.

Working: On a straight road the cage, planet pinions and sun gears rotate together as one unit — both wheels at cage speed. On a turn, the inner wheel slows down; the planet pinions spin on their pin and the outer sun gear speeds up by the same amount. $N_{\text{inner}} + N_{\text{outer}} = 2 N_{\text{cage}}$.

Numerical: $N_{\text{cage}} = 400$ rpm, $R = 10$ m (centre line), track $t = 1.4$ m.

Radius of inner wheel path $R_i = R - t/2 = 10 - 0.7 = 9.3$ m; outer $R_o = R + t/2 = 10.7$ m.

Wheel speed is proportional to the radius of its path (same angular velocity of vehicle about the turning centre), and the cage speed corresponds to radius R :

$N_{\text{inner}} = 400 \times 9.3 / 10 = 372$ rpm; $N_{\text{outer}} = 400 \times 10.7 / 10 = 428$ rpm.

Check: $372 + 428 = 800 = 2 \times 400$ ✓

(Sketch 2 M, construction and working 2 M, numerical 2 M)

b) MacPherson strut — construction, working, advantages, disadvantages.

6 M

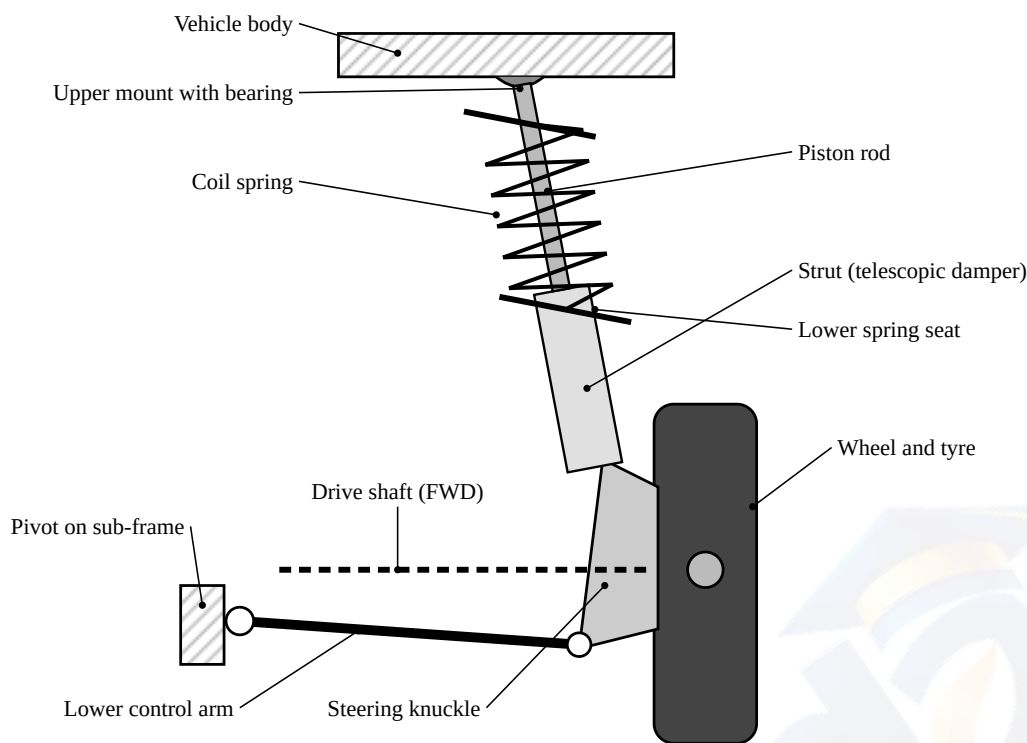


Fig. MacPherson strut type independent front suspension (front view, RH side)

Construction: The MacPherson strut combines the shock absorber and the coil spring in one unit. The lower end of the strut is bolted rigidly to the steering knuckle; the upper end is mounted on the body (strut tower) through a rubber mount with a thrust bearing. The coil spring sits between a lower seat on the strut tube and an upper seat under the mount. The lower end of the knuckle is connected through a ball joint to a lower control arm (transverse link), pivoted on the sub-frame. An anti-roll bar is often connected to the arm.

Working: When the wheel rises over a bump, the strut tube slides up over the piston rod, compressing the spring; the spring absorbs the shock and the damper controls rebound. The lower arm swings about its pivot to guide the wheel. During steering, the strut and knuckle turn together about the axis through the upper mount and lower ball joint.

Advantages	Disadvantages
Simple, light, fewer parts, low cost.	Tall strut needs more height — bonnet line is raised.
Compact — more space for transverse engine (FWD).	Camber changes with wheel travel; less ideal geometry than double wishbone.
Less unsprung weight; good ride.	Road noise and vibrations are transmitted to the body through the strut top.
Wide spacing of mounting points reduces loads on body.	Strut rod is subjected to side loads — friction and wear of seals.

(Sketch 2 M, construction and working 2 M, advantages 1 M, disadvantages 1 M)

c) Semi-floating axle; comparison.

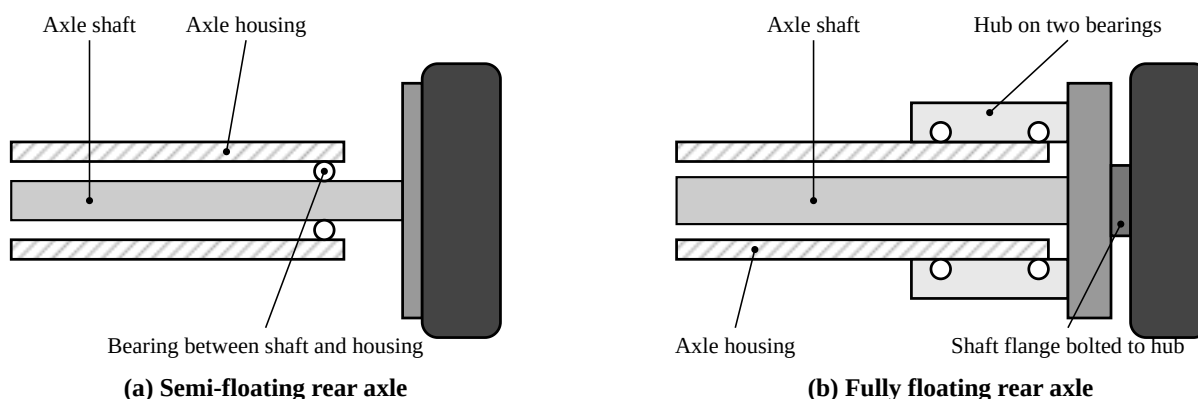


Fig. Types of rear axle (half sections at wheel end)

Semi-floating rear axle: The inner end of the axle shaft is splined to the differential sun gear; the outer end carries the wheel hub directly (by key/taper or flange). A single ball/roller bearing is placed between the axle shaft and the axle housing near the wheel. The axle shaft transmits the driving torque and also supports the vertical load, side thrust and braking torque, so it is subjected to bending, shear and torsion. It is simple, light and cheap; used in cars and light commercial vehicles.

Point	Semi-floating	Fully floating
Loads carried by shaft	Torque + weight + side thrust + braking load	Only driving torque
Bearing arrangement	One bearing between shaft and housing	Two bearings between hub and housing
Shaft size	Larger diameter needed	Smaller for same torque
Removal of shaft	Wheel has to be removed first	Shaft removed without removing wheel
Safety if shaft breaks	Wheel may come off	Wheel remains on housing
Cost / application	Cheap — cars, light vehicles	Costly — trucks, buses

(Sketch 2 M, explanation 2 M, comparison 2 M)

Q.6

a) Layouts of FEFWD and 4WD; advantages.

6 M

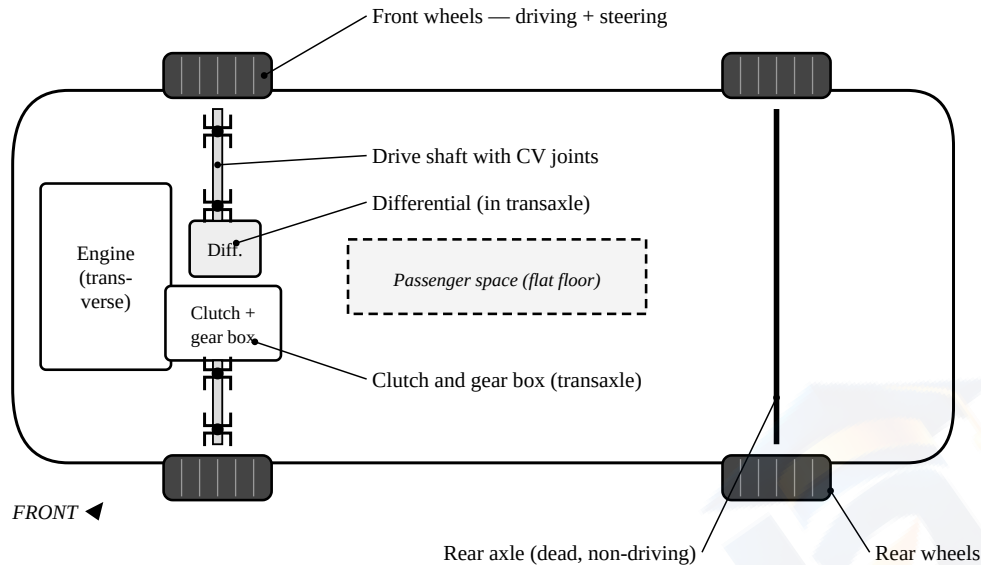


Fig. Front engine front wheel drive (FEFWD) layout — plan view

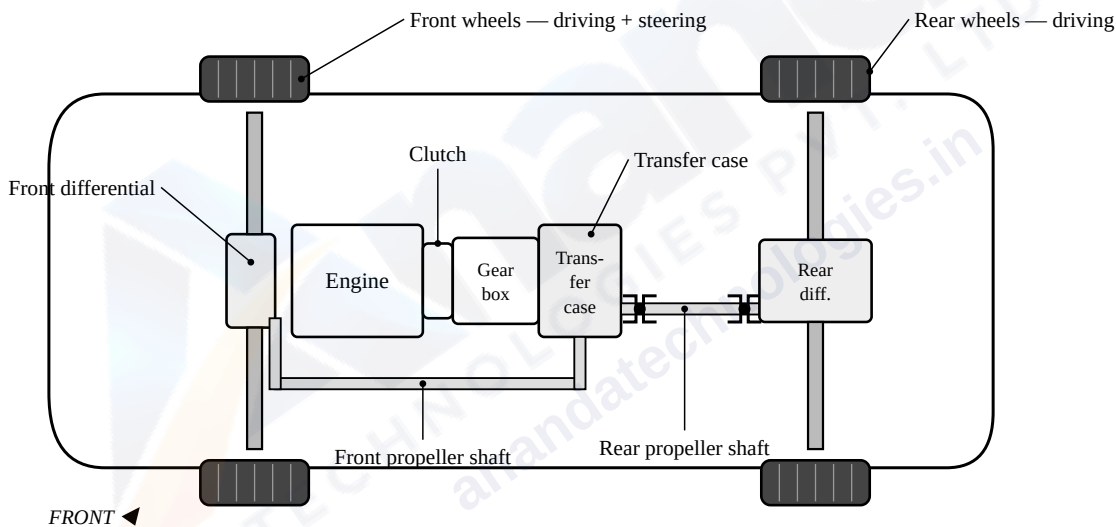


Fig. Four wheel drive (4WD) layout — plan view

FEFWD: engine, clutch, gear box and differential form one unit at the front; drive shafts with CV joints drive the front wheels, which also steer.

Advantages: no propeller shaft — flat floor and more cabin space; better traction on slippery roads because engine weight is on driving wheels; lighter and cheaper; good straight-line stability.

4WD: engine and gear box at front; a **transfer case** behind the gear box divides power between front and rear propeller shafts, which drive front and rear differentials. All four wheels are driven (driver can select 2WD/4WD and high/low range).

Advantages: maximum traction — suitable for off-road, mud, sand, snow and steep hills; better pulling power and stability on bad roads; low range gives very high torque for difficult terrain.

(Two layouts 2 M each, advantages 1 M each)

b) Requirements of steering; steering linkage for rigid axle.

6 M

Requirements: light and easy operation; precise control with minimum play; self-centering after a turn; road shocks should not reach the driver; correct turning (true rolling) of wheels to minimise tyre wear; reliable and needing little maintenance.

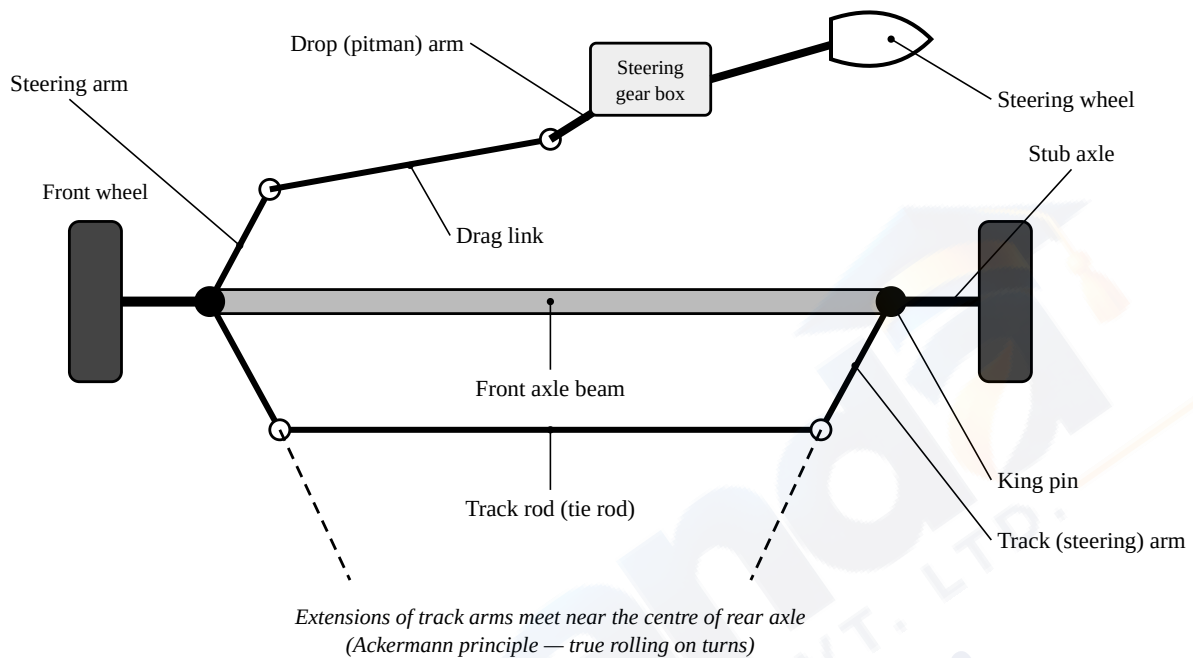


Fig. Steering linkage for rigid front axle (Ackermann type) — plan view

Steering linkage (rigid front axle): The steering wheel turns the steering shaft and the steering gear box (worm and sector / recirculating ball). The output of the gear box swings the **drop (pitman) arm**, which moves the **drag link** forward and backward. The drag link is connected to the **steering arm** on the left stub axle, which turns about the **king pin** on the front axle beam. The two stub axles are connected through **track arms** and a **track (tie) rod**, so that the right wheel also turns. All joints are ball joints to allow movement in all directions.

The track arms are inclined inward so that their extensions meet near the centre of the rear axle (Ackermann principle); hence on a turn the inner wheel turns through a larger angle than the outer, and all wheels roll about a common centre without side slip.

(Requirements 1 M, sketch 3 M, explanation 2 M)

c) Magneto ignition; comparison with battery ignition.

6 M

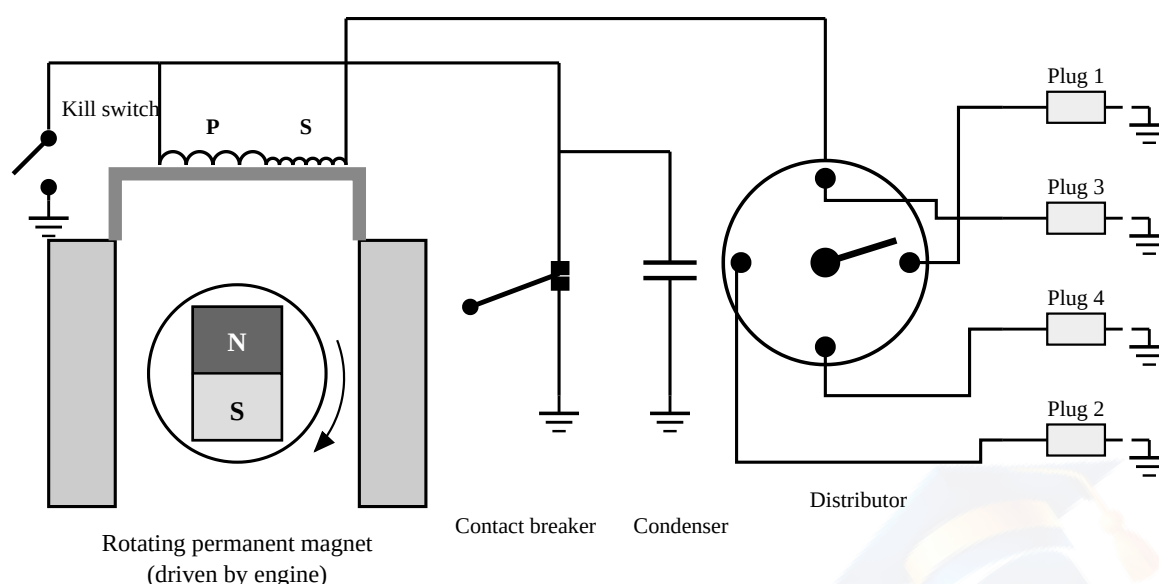


Fig. Magneto ignition system (rotating magnet type)

Working: The magneto is an engine-driven generator which produces its own primary current — no battery is needed. A permanent magnet rotates between the pole shoes of a soft iron armature core carrying primary and secondary windings. As the magnet rotates, the magnetic flux through the core reverses and induces current in the primary winding, which flows through the closed contact breaker. When the primary current is maximum, the cam opens the CB points; the current stops suddenly and the rapid collapse of flux induces a very high voltage in the secondary winding. This is sent through the distributor to the spark plugs. The condenser prevents arcing at the points. The engine is stopped by the kill switch, which earths the primary circuit.

Point	Battery ignition	Magneto ignition
Source of primary current	Battery	Magneto (generates its own current)
Starting	Good spark even at low cranking speed — easy starting	Weak spark at low speed — starting difficult
Spark intensity vs speed	Decreases at high speed	Increases with engine speed
Maintenance	Battery needs charging/maintenance	No battery — less maintenance
Space / cost	Occupies more space; cheaper	Compact; costlier
Application	Cars, buses, trucks	Two-wheelers, racing cars, aircraft piston engines, small engines

(Sketch 2 M, working 2 M, comparison 2 M)

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