



Scout Mechanic Activity Badge

Leader's Guide – Option 1: Motor Car

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Introduction

The Army is delighted to be working in association with the Scouts to inspire and enthuse young people about science, technology, engineering and maths. Operating at the leading edge of technology, the Army relies on a constant inflow of talented and motivated young people to help us undertake our role as part of the UK's Defence and as an emblem for good around the world. We hope this Leader's Guide in support of the Mechanic Activity Badge, will give Scouts insight into the world of mechanics and technology. To find out more about the partnership, visit scouts.org.uk/the-british-army.

This resource contains step-by-step instructions for each requirement to support the leader with this badge. For further support, a glossary of terms is provided on page 21

What are the requirements?

Option 1: Motor Car

Here's what your Scouts need to do to earn this badge:

1. How a combustion engine works

Learn the principles of operating an internal combustion engine. Understand the function of the clutch, gearbox and rear axle differential.

2. Windscreen wash bottle

Show how to check and refill the windscreen wash bottle of a car with the correct fluid mix.

3. Headlight bulbs

Show how to change a bulb at the front and rear light clusters of a car.

4. Radiator

Show how to check the level of coolant in the radiator, 'top up' the radiator and explain the importance of anti-freeze.

5. Tyre pressure

Show how to check tyre pressures and inflate a tyre correctly.

6. Road wheels

Remove and replace a road wheel safely.

7. Road tyres

Explain what to look for when checking that a tyre conforms to the law. Find out why cross and radial ply tyres should not be mixed on the same axle.

8. Wiper blades

Show how to change a wiper blade.

9. MOT road test

Explain the outline requirements for the MOT test.

Safety guidance - Remember to do a risk assessment and follow the manufacture's guidelines at all times.

The requirements for Option 2: power boat; Option 3: aircraft; Option 4: motorcycle or scooter can be found on the members' area of scouts.org.uk.

Flexibility

Each young person who participates in the programme should face a similar degree of challenge, and badge requirements can be adapted according to each young person's abilities. For more information and practical tips see our guidance on inclusivity at scouts.org.uk/diversity.

Disclaimer

Please note that these are the requirements for the Scout Mechanic Activity Badge at the time of going to print. For up to date information and badge requirements, please visit the members' area of scouts.org.uk

Requirement 1

Principles of an Internal Combustion Engine.

An internal combustion engine is one in which energy is produced when fuel is burnt in the cylinders within the engine. It involves the conversion of heat energy from the combustion (process of burning) to mechanical energy. In petrol engines a spark from the spark plug causes the fuel to burn. In diesel engines hot air causes the fuel to burn.

A four-stroke petrol combustion engine is the most common type of small engine, and completes this conversion in four stages (strokes).

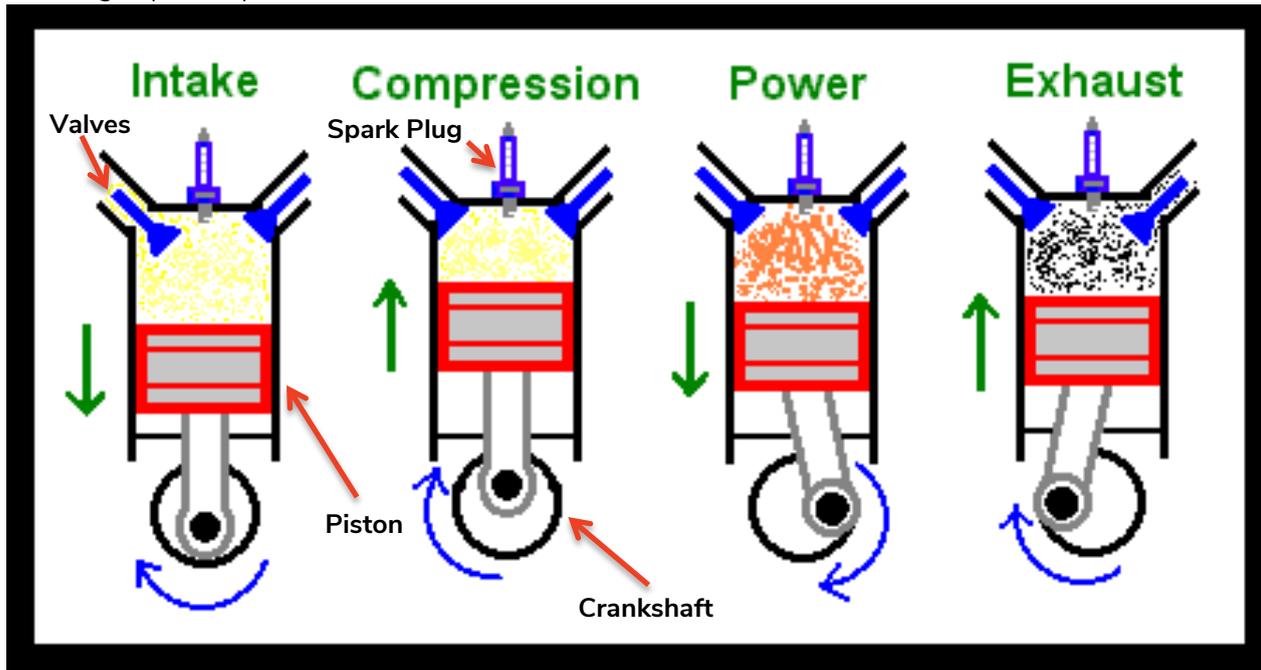


Fig. 1 – Internal Combustion Engine (<http://www.myschoolhouse.com/courses/O/1/143.asp>)

Valves at the top of the cylinder open and close as the piston rises and falls. The timing of these valves is critical to the smooth running of the engine. If the timing is out, the engine 'misfires' and may stop working all together.

Stage 1 - Intake stroke (Suck)

As the piston descends, it sucks a mixture fresh air and petrol into the cylinder.

Stage 2 - Compression stroke (Squeeze)

The piston rises and compresses the fuel/air mixture.

Stage 3 - Power stroke (Bang)

The spark plug flashes and ignites the air/fuel mixture. The explosion is a rapid expansion of gasses, which force the piston back down the cylinder. This transfers torque (turning motion) to the crankshaft that then delivers the turning motion to the wheel via the gearbox.

Stage 4 - Exhaust stroke (Blow)

The burnt air/fuel mixture is forced out of the exhaust valves, as the piston travels back up the cylinder. Once all four strokes are complete the piston is back at the start and ready to do it all again. Larger, more powerful engines have more than one piston and their four strokes are coordinated, eg in a two-piston engine, when one piston is squeezing, the other is blowing. They are connected to each other by the crankshaft.

Function of the Clutch.

In a car, the transmission is the system of gears and shafts by which the power from the engine reaches and turns the wheels. When the engine is on, its working parts spin all the time. However, the transmission does not and is needed to move the wheels. The clutch is a mechanical device that sits between the engine and the transmission (see Fig 2) which engages/disengages the spinning parts of the engine from the transmission system of the vehicle at the will of the driver.

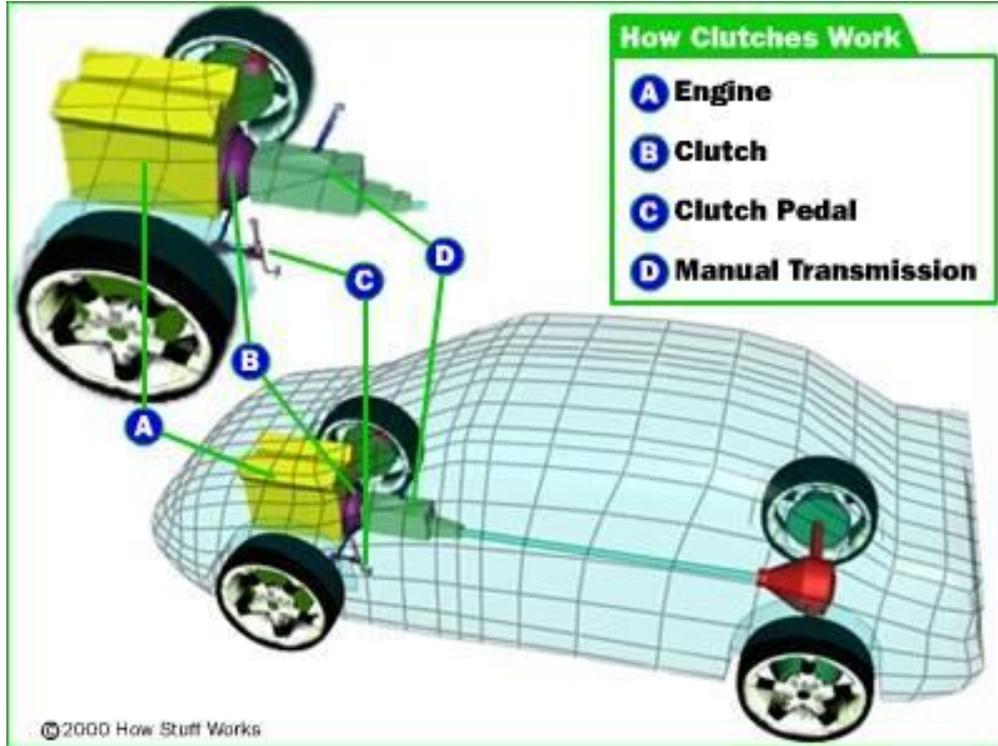


Fig 2 – How clutches work (<https://auto.howstuffworks.com/clutch.htm>)

The clutch allows transmission to be interrupted by disengaging the engine, by pressing the clutch pedal (see Engine A in Fig 3) while a gear is selected to move off from a stationary position or when gears are changed while the car is moving, for example to go up a hill or to overtake another vehicle. The clutch pedal is then released (see Engine B in Fig 3) and the engine is once again engaged with the transmission

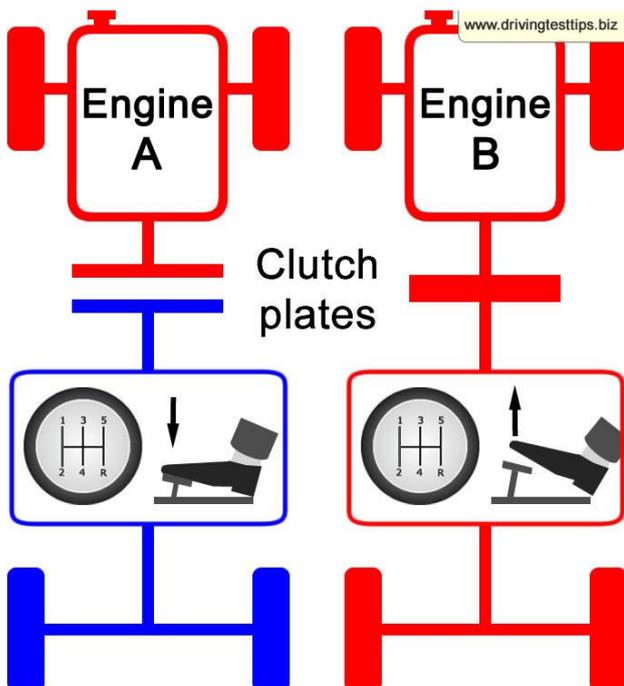


Fig 3 – Clutch operation diagram (<https://www.drivingtesttips.biz/wp-content/uploads/2014/05/clutch-description-diagram2.jpg>)

Functions of a Gear Box.

The gearbox is part of the transmission. It sits behind the clutch (see Fig 4 below) and provides a selection of gears for different driving conditions: standing start, climbing a hill, or cruising on level surfaces.

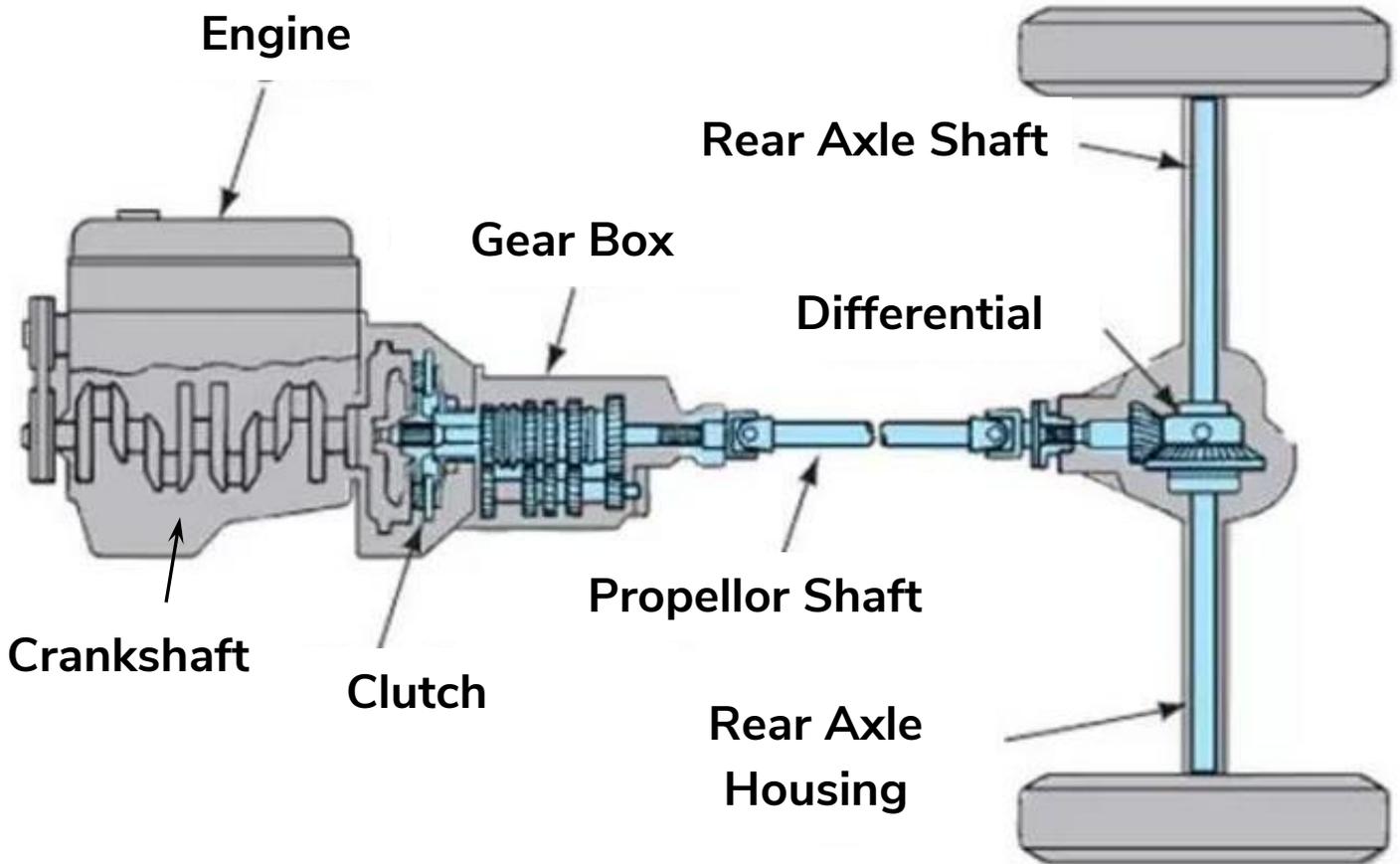


Fig 4 – Diagram of a transmission (<https://carsintrend.com/car-layout-types/>)

Did you know?

The Royal Electrical and Mechanical Engineers (REME) are the Army's specialists at changing gear boxes.

Functions of Rear Axle Differentials.

The differential in a car is a mechanical device that re-directs the power from the engine through 90 degrees to the wheels. It also allows the wheels to spin at different speeds, for example when turning into a corner the inside wheel turns more slowly than the outside wheel as it has a shorter distance to travel.

In a rear wheel drive car, the rear wheels are the ones that receive the power from the engine and that are driven, and the front wheels are just used for steering. The differential is on the rear axle. (See fig 5 below)

In a front wheel drive car, the front wheels receive the power and the differential is on the front axle. (See fig 5 below)

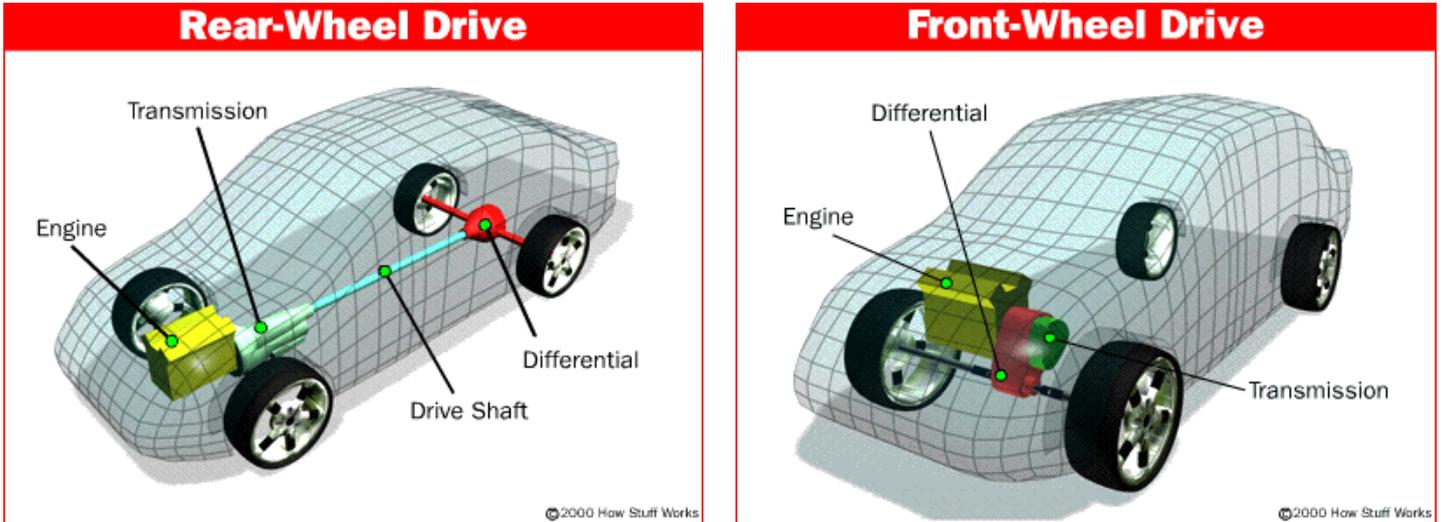


Fig 5 – Rear Wheel and Front Wheel Drive (<https://auto.howstuffworks.com/differential1.htm>)

A four-wheel drive car has two differentials, one on the front axle and one on the rear axle. Power from the engine is re-directed to all four wheels, allowing them all to be driven, which gives the car more traction (grip on the road). The four-wheel drive function can be turned on or off by the driver depending on the driving conditions.

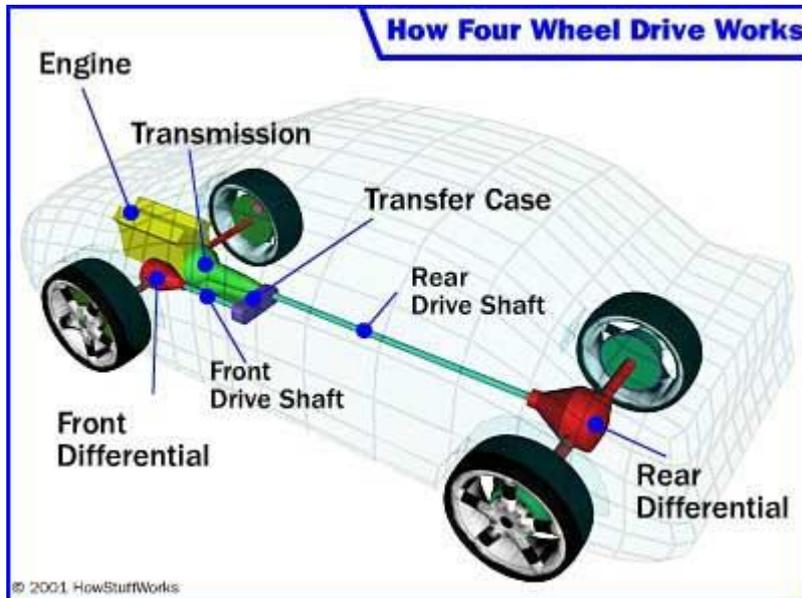


Fig 6 – Four-Wheel Drive (<https://auto.howstuffworks.com/four-wheel-drive.htm>)

Requirement 2

Show how to check and refill the windscreen wash bottle of a car.

*Safety Guidance – Avoid completing this activity if the engine is still warm to avoid a burn.
Make sure the support strut is fully secure before completing any activities under the bonnet.
Keep washer fluid away from young people unless supervised.*

We suggest that as part of this activity you should take the time to explain the hazards of using washer fluid (and other liquids, such as coolant, brake fluid and oil); how it can be harmful to the skin and very dangerous to ingest if used inappropriately.

STEP 1 – Find the bonnet release catch. The location of this will vary depending on the make and model of the car. If you are unsure where to find the bonnet release catch, check in the vehicle's Owner's Manual. You will then need to find the latch under the bonnet to fully open the bonnet, then use the support strut to secure the bonnet in the open position.



STEP 2 – Find the washer fluid cap, which will have a washer fluid symbol on it, similar to the one pictured below. Remove the cap and visually check the level of fluid.



STEP 3 – Top up the washer fluid with the required amount of screen-wash and water (according to the instructions on the bottle). Fill it up to the maximum line. If this is not visible, keep pouring until the fluid reaches the top of the filler tube. Remember to replace the washer fluid cap and screenwash lid when you're finished.



Requirement 3

Show how to change a bulb at the front and rear light cluster of a car.

STEP 1 – With the engine and ignition turned off find the bonnet release catch and secure the bonnet in the open position, as described in Step 1 of the screenwash activity on page 8. The rear light cluster can be accessed through the boot.



STEP 2 – Refer to the Owner's Manual and identify how to access the light cluster. Remove any rubber waterproof covers in order to gain access to the light bulbs inside.



STEP 3 – Unclip the housing securing the bulb in place, disconnect the wire from the bulb and remove the old bulb from the light cluster. Replace with the new bulb and reconnect the wires in the same pattern.

Safety Guidance - Do not touch the glass of bulbs directly with your hands. The reason for this is that halogen bulbs can get very hot when they are operating. They need to heat evenly and if you leave any trace of grease on the bulbs from your fingers, it can cause uneven heating when the bulb is in use and this means that the bulb will not last as long.



STEP 4 – Secure the bulb in place with the wire clip and replace the waterproof covers securely.

Requirement 4

Show how to check the level of coolant in the radiator, 'top up' the radiator and explain the importance of anti-freeze.

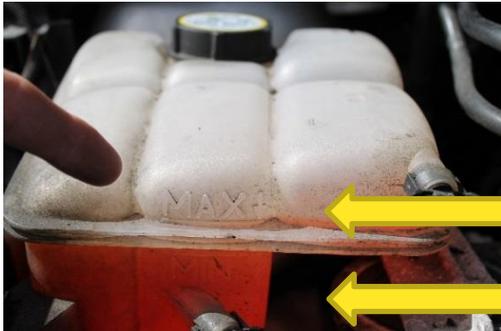
Safety guidance - Complete the check when the engine is cold. Make sure the support strut is fully secure before completing any activities under the bonnet. Keep coolant away from young people unless supervised.

We suggest that as part of this activity you should take the time to explain the hazards of using coolant (and other liquids, such as washer fluid, brake fluid and oil); how it can be harmful to the skin and very dangerous to ingest if used inappropriately.

STEP 1 – With the engine and ignition turned off find the bonnet release catch and secure the bonnet in the open position, as described in Step 1 of the screenwash activity on page 8.



STEP 2 – After locating the radiator overflow tank, check the level using the manufactures level marks.



Maximum Level

Minimum Level

STEP 3 – If low – remove the expansion cap (using a cloth to protect your hand) and top up the level using manufacturers guidelines, from the Owner's manual, with the correct mix of water and coolant. DO NOT OVERFILL.



STEP 4 – Replace the expansion cap, run engine to normal working temperature and recheck levels.

Top Tip - The coolant is usually a mix of water and anti-freeze liquid (which keeps the coolant flowing, even when it is very cold weather).

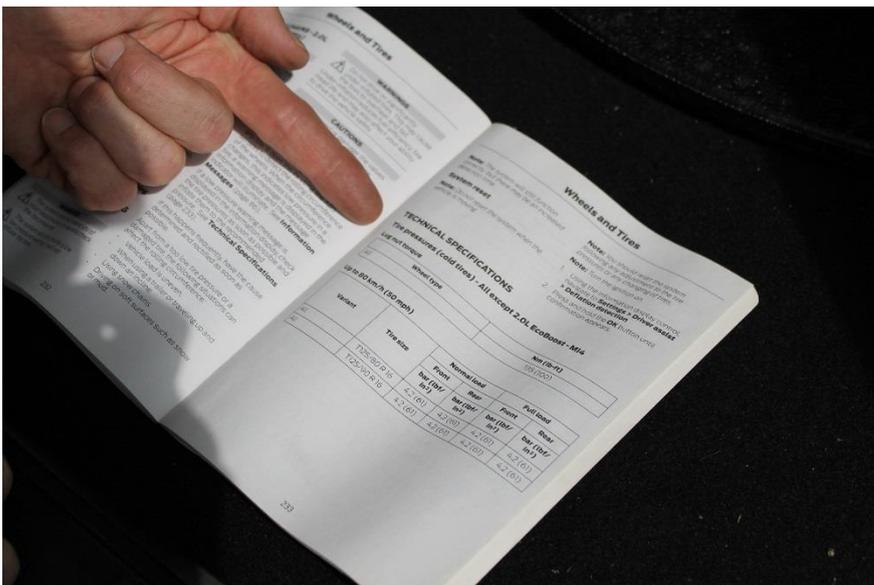
Requirement 5

Show how to check tyre pressures and inflate a tyre correctly.

Different types of tyre pressure gauges:



STEP 1 – Find the correct tyre pressure. Look for a sticker normally located in the door frame or read the vehicle's Owner's Manual. Tyre pressure can be measured in BAR or PSI. 1 Bar is the roughly the same as atmospheric pressure at sea level and PSI is 1 pound of force per square inch. You can use an online converter to quickly convert from one measurement to the other.



STEP 2 – Remove the dust caps from the car's tyres. These are small covers used to protect the valves of the tyres and can be removed by unscrewing them.

Top Tip

Always put the dustcaps somewhere safe. They are so small they can easily get lost!



STEP 3 – Place your tyre pressure gauge over the tyre valve for approximately three seconds. Ensure no loss of air to guarantee correct pressure is read. If using a pen-type gauge, make sure the sliding scale is pushed fully in before testing the pressure.



STEP 4 – If the tyre pressure is too low, use an appropriate pump to slowly inflate the car tyre, to the correct pressure. Once complete, ensure the dust caps are re-fitted to prevent ingress of dirt or small particles that could damage the valve.

Top tip

Remember that not inflating your car tyre pressure correctly will cause the tyre to wear unevenly and will affect the performance of your car. The image below shows how tyres wear in different areas depending on how they are inflated.

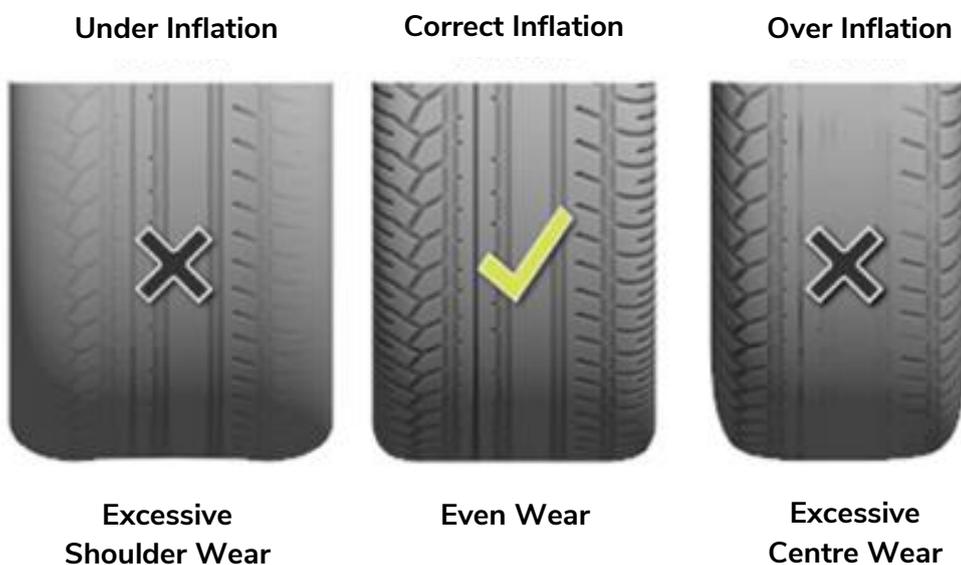


Fig 6 – Tyre wear (<https://www.motorbeam.com/5-tips-maintain-tyres/>)

Requirement 6

Remove and replace a road wheel.

Safety guidance – Complete the requirement in a safe place away from traffic, such as a car park, and ensure the car is on a flat, hard surface, with the hand brake on.



STEP 1 – If on a public road, put on your high-visibility vest, place the warning triangle at least 45m behind the vehicle and turn on the hazard lights. Always be aware of passing traffic. If in doubt call a breakdown service and never attempt to change a tyre on a motorway. With the vehicle secure on a flat, hard surface, apply the parking brake and chock the wheels to stop the vehicle rolling.



STEP 2 - Using an appropriate wheel brace slightly loosen the wheel nuts. Some cars have locking nuts to protect the wheels from theft. A special key is required to remove them. **DO NOT REMOVE THE NUTS COMPLETELY AT THIS STAGE.**



STEP 3 – Locate the jacking point using the vehicle Owner's Manual and position the jack. Using an appropriate jack handle, raise and secure the vehicle.



STEP 4 – Remove the wheel nuts and remove the wheel.

Top Tip

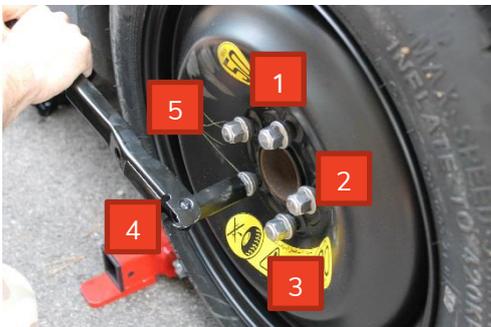
Put the wheel nuts somewhere safe as they are easily lost!



STEP 5 – Refit a serviceable wheel by lining up the holes with the threaded studs and pushing the wheel fully back on the wheel hub.



STEP 6 – Evenly tighten up the wheel nuts by hand until the wheel is sitting snugly on the axle hub.



STEP 7 – Gently lower the vehicle and tighten the wheel nuts using the wheel brace. Tighten up the 'opposites' ie, in the following order – 1, 4, 2, 5, 3. Check tyre pressure and adjust if necessary.

STEP 8 – When it is safe to do so, remove the warning triangle from the road and turn off your hazard lights.

Requirement 7

Explain what to look for when checking that a tyre conforms to the legal requirement.

The tread depth is the depth of the grooves on a tyre. The law requires car tyres to have a minimum tread depth (as indicated in the photo below) of 1.6mm in a continuous band around the central three quarters of the tyre. The tyre should also have no splits or bulges in the side (these indicate internal damage and weak points).



Manufacturers often mould small indicator tread bars at 1.6mm, as shown above, for a quick visual check. Once your tyre reaches the tread bar you must change your tyres.



Your tyre tread depth can be measured using a tread depth gauge (as shown in the photo above).

A quick test to see if your tyre tread exceeds the minimum legal tread depth is the 20p test.



Above Legal Limit



Below Legal Limit

Place a 20p coin into the main tread grooves of your tyre. If the outer band of the 20p coin is obscured when it is inserted, then your tread is above the legal limit.

Find out why cross and radial ply tyres should not be mixed on the same axle.

Radial-ply tyres

Radial tyres were developed in 1946 by Michelin and these are now the most common tyres in use on British roads. All tyres have a carcass of cords of polyester, steel, or other textile materials, inlaid with several layers of rubber. A radial-ply tyre is constructed on a base of layers of fabric that are laid radially (ie coming from the same centre point – see below). This means that the sidewalls of radial tyres are very flexible whilst still retaining their strength. This flexibility of the sidewall enhances vehicle stability and allows greater control over the direction of the tyre on the road. It also allows the tyre to retain its contact with the road on corners. These tyres also generate less heat and so they do not wear out as quickly.

Cross-ply tyres

Cross-ply tyres consist of layers made from nylon cord that are placed diagonally across each other, as shown below. They have rigid sidewalls. This rigid sidewall and the general design of the tyre don't allow heat to dissipate as effectively and the tyre wears out faster.

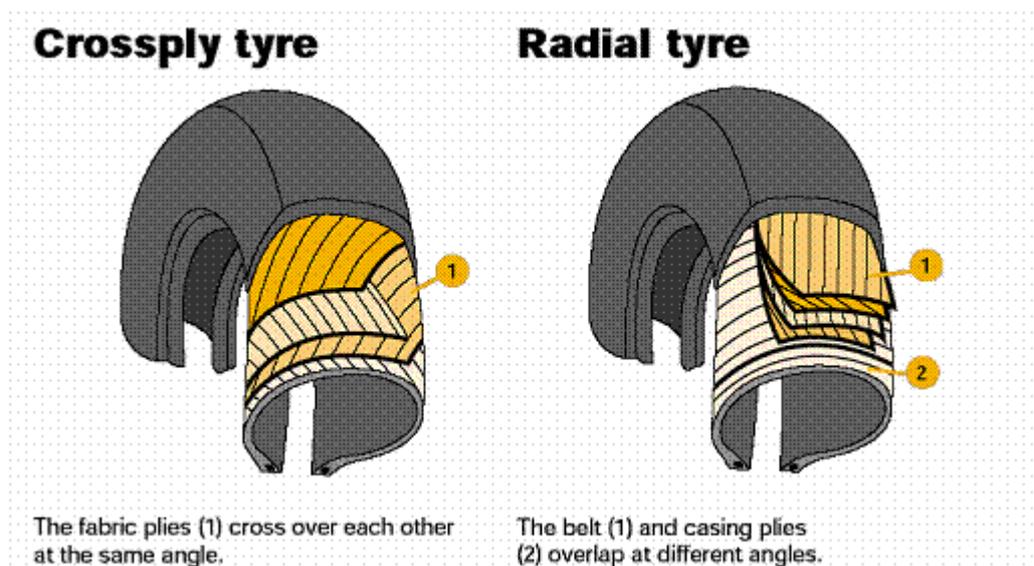


Fig 7 – Crossply and radial tyre (<https://www.quora.com/What-is-the-difference-between-radial-and-non-radial-tires>)

Because of the different construction of the tyres gives them different handling characteristics they should not be mixed.

Requirement 8

Show how to change a wiper blade.

You should change your wiper blades when the blades smear or don't clear water from the screen efficiently.

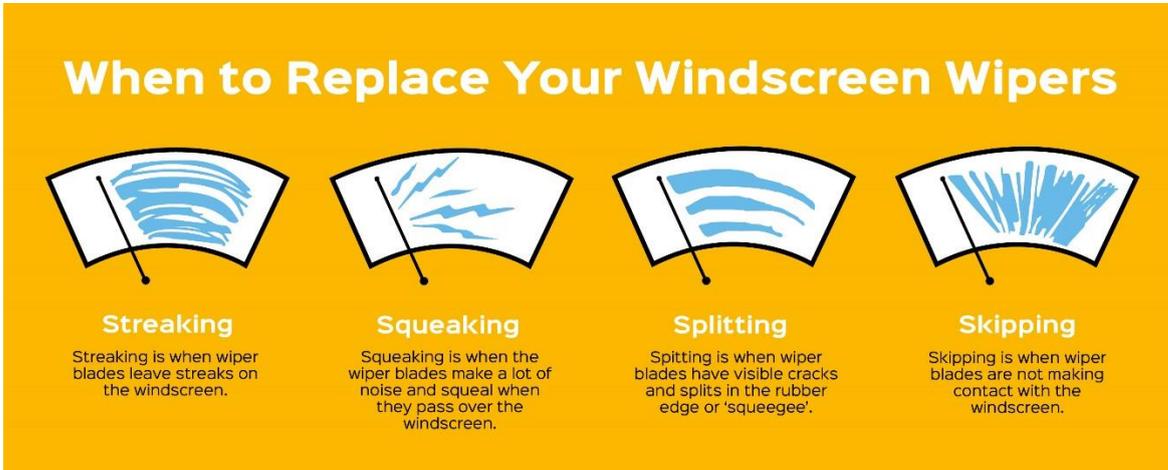


Fig 8 - Times when you should change a wiper blade (<https://www.kwik-fit.com/blog/is-it-time-for-new-windscreen-wipers>)

How to change windscreen wiper blades

Top Tip

There are many different types, sizes of wipers and fitting clips, so consult the car's owners manual as to the right blades for your vehicle.



STEP 1 – Gently pull the wiper arms away from the car windscreen. They are spring loaded, so there will be some initial resistance, but once they are in the air they should stay there.



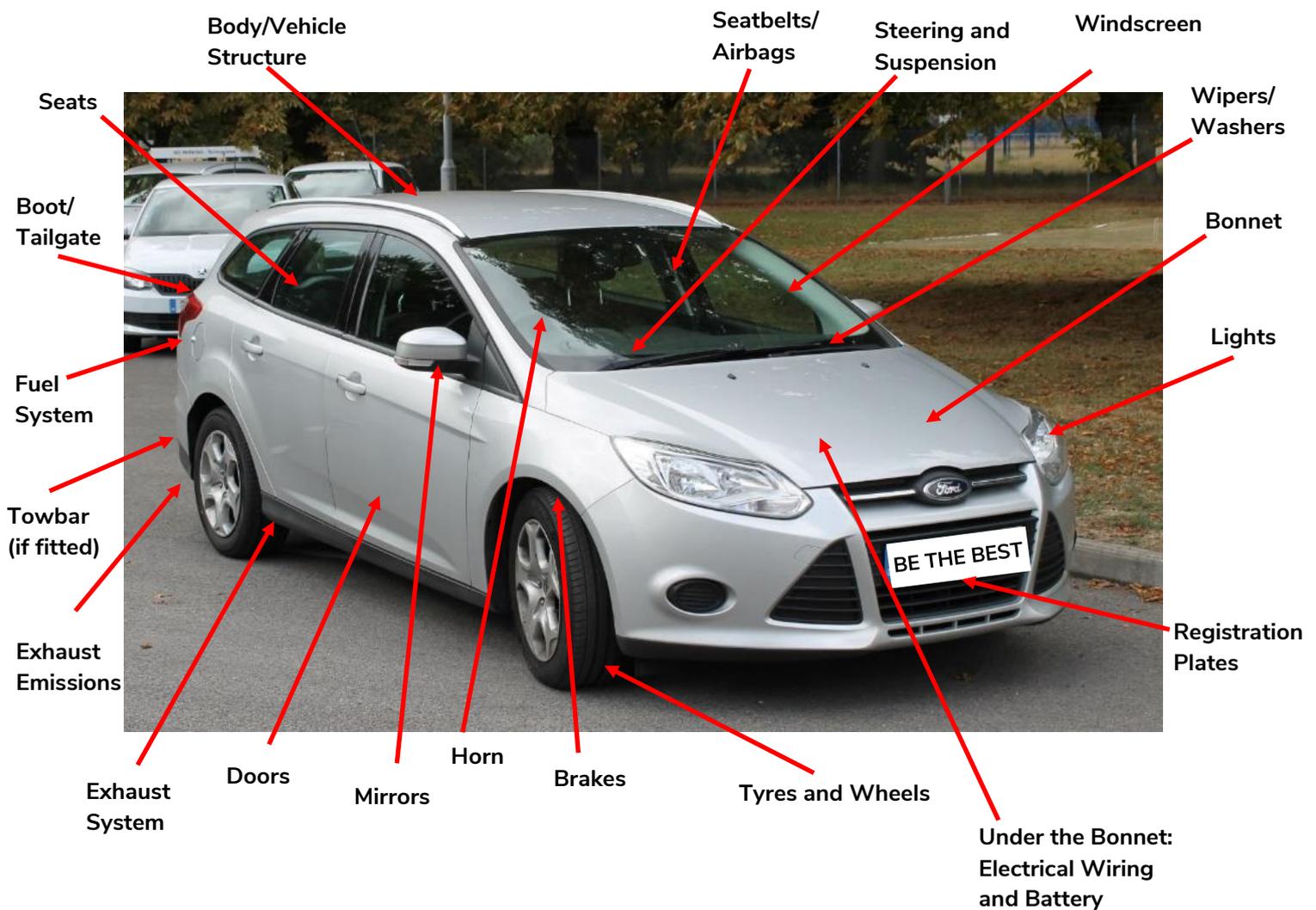
STEP 2 – Cars have different types of wiper connectors. If you're unsure, check your owner's manual. Unclip the wiper from the arm and remove. Reverse the process to fit the new blade.

STEP 3 - Once the new blade is in place, gently lay the wiper arm back down, taking care not to damage the windscreen.

Requirement 9

Explain the outline requirements for an MOT road test.

The Ministry of Transport (MoT) vehicle test is a legal requirement to ensure vehicles travelling on UK roads are safe. It is an annual test that all vehicles over three years old must pass if they are to be used on a public road. The test covers the parts of the car shown below and looks at whether the areas are functioning as they should. Further information can be found at <http://bit.ly/2RvPUdY>



How to check and top-up oil.

Safety guidance - Complete this check when the engine is cold. Make sure the support strut is fully secure before completing any activities under the bonnet. Keep oil away from young people unless supervised.

We suggest that as part of this activity you should take the time to explain the hazards of using oil (and other liquids, such as washer fluid, brake fluid and coolant); how it can be harmful to the skin and very dangerous to ingest if used inappropriately.

STEP 1 – With the Engine and ignition turned off find the bonnet release catch and secure the bonnet in the open position, as described in Step 1 of the screenwash activity on page 8.



STEP 2 – Locate the oil filler cap and dipstick. Make sure that you have a clean, lint-free rag or paper towel that can be used to wipe the dipstick clean.



STEP 3 – Remove the dip stick and wipe it on the rag, to remove the oil.



Maximum Level

Minimum Level

STEP 4 – Insert the dipstick back into the tank fully. Pull the dipstick out and look at how far the oil has travelled up the scale. If the oil is a lot closer to the minimum level, additional oil will need to be added.



STEP 5 – If you need to add more oil, put the dipstick back into its tube and remove the oil filler cap. Pour some oil in (using a funnel if required) and give it time to drain into the bottom of the engine, then re-check the level. Follow the Owner’s Manual to avoid overfilling as that can cause leaks, so take your time.

Glossary of Terms.

Anti-freeze - is a chemical liquid that is added to the cooling water of an engine to stop it from freezing in cold weather.

Axle – An axle is a rod which is connected to the centre of a wheel. For a wheel to turn it needs an axle. The axle keeps the wheels an equal distance from each other. If a vehicle did not have an axle then it would not be able to work. In many vehicles, the wheels are the only things touching the ground. This means the axle must be very sturdy, so that it can bear the weight of the vehicle and any cargo.

Chock - a wedge or block placed against a wheel or rounded object, to prevent it from moving.

Crankshaft – The crankshaft runs inside the bottom end of the engine and converts the vertical movement of the pistons into horizontal rotational movement.

Differential – The differential allows the outer drive wheel to rotate faster than the inner drive wheel during a turn. This is necessary when the vehicle turns, making the wheel that is travelling around the outside of the turning curve roll further and faster than the wheel that is travelling around the shorter, inside of the turning curve.

Piston – The piston is the moving component that is contained in a cylinder and is made gas-tight by piston rings. After the piston compresses the fuel-air mixture, the spark ignites it, causing combustion. The expansion of the combustion gases pushes the piston during the power stroke.

Radiator – A radiator is a type of heat exchanger. It is designed to transfer heat from the hot coolant that flows through it to the cold air blown through it by the fan.

Radiator Overflow Tank - A radiator overflow tank collects the expanding coolant that is heated by the engine and recycles it back into the coolant system once it loses enough heat. The radiator overflow tank works in conjunction with the radiator cap to protect the engine and prevent coolant loss due to overflow.

Spark Plug – A spark plug is a device in the engine of a vehicle which produces electric sparks to make the fuel burn. The plug is connected to the ignition coil that generates the high voltage electricity needed to spark the fuel and create combustion within your engine. No spark plug means no combustion, which means the car will not be going anywhere without one. (Note that diesel fuelled engines are designed differently and have no spark plugs)

Torque - Torque is a measure of how much a force acting on an object causes that object to rotate.

Transmission – the Transmission is the system of gears and shafts by which the power from the engine reaches and turns the wheels.

Automatic Transmission – the vehicle changes gears without assistance from the driver.

Manual Transmission – gears are changed by the driver using the clutch pedal.

Valve – Engine valves are found in the cylinder head at the top of the engine. The main function of the engine valves is to let air in and out of the cylinders. That air is used to help ignite the fuel which will drive the pistons up and down.

Wheel Brace – A wheel brace is a tool for screwing and unscrewing nuts on the wheel of a vehicle.