

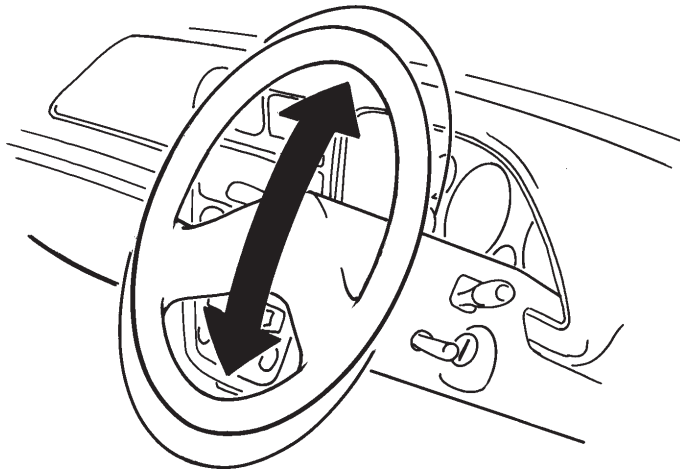
# CAD/CAM: DESIGNING AND MODELLING AN ADJUSTABLE RAKE STEERING COLUMN

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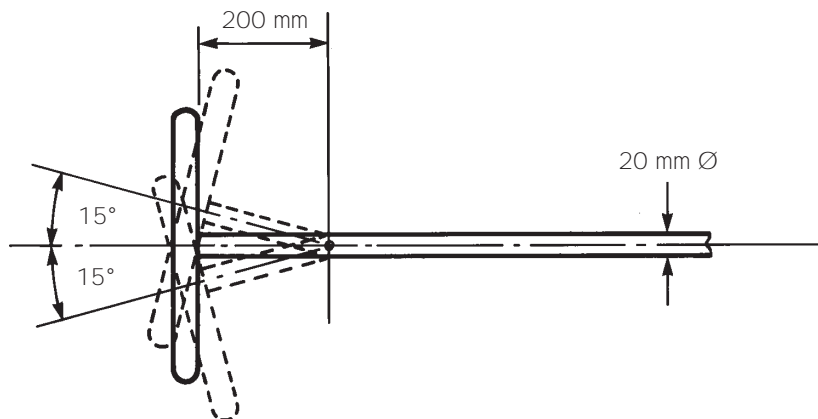
Project originated by Kevin Morgan, Dagenham Priory School

## DESIGN CONTEXT

Many motor cars are now equipped with adjustable steering wheels in order to make the driver's position more comfortable and safe.



For this adjustment to take place, there needs to be a joint in the steering column, allowing it to 'bend' along its axis whilst still allowing rotational movement to be transmitted from one end of the shaft to the other. The range of adjustment needed is 15° (degrees) either side of the shaft's natural axis.



There are two parts to this task:

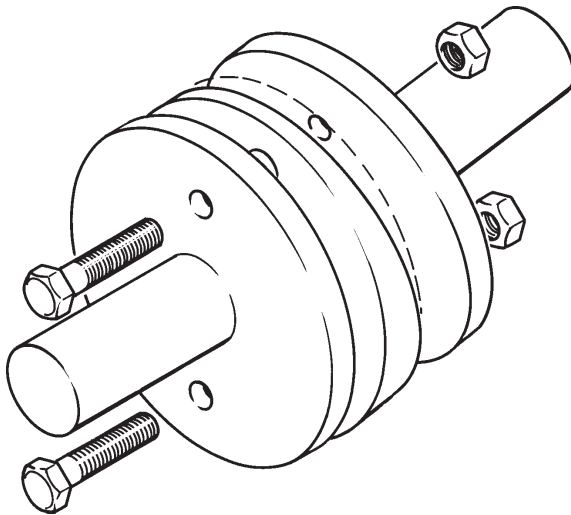
1. the design and manufacture of a joint that will allow the shaft to rotate when the steering wheel is not in line with the natural axis.
2. the design and manufacture of the means of adjusting the angle of the steering wheel (its 'attitude'). This needs to be easy to achieve, and secure once adjusted.

### 1. TILTING THE STEERING WHEEL - TRANSMITTING MOVEMENT AT AN ANGLE

Any place where a shaft is split needs a **coupling** to allow rotational movement to be transmitted.

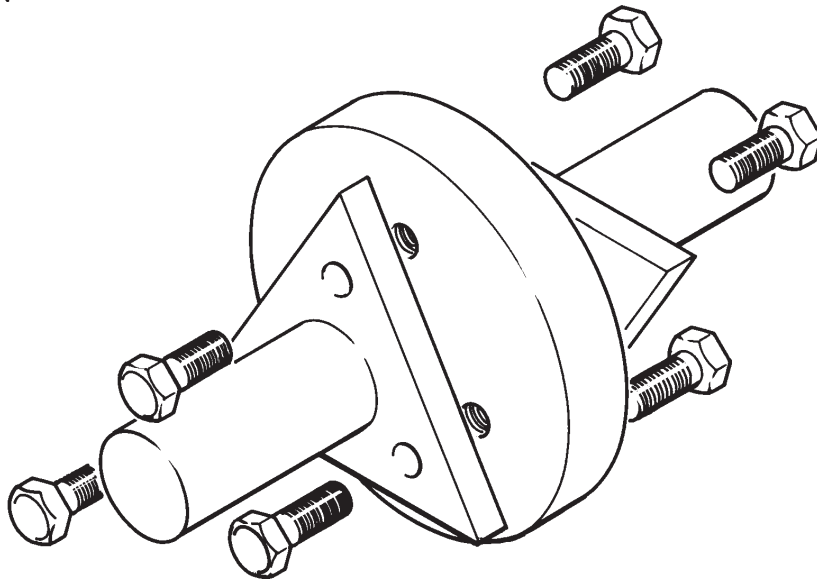
Simple coupling of shafts that are in alignment is easy - **collars** and **flanges** can be used.

Flange joint:

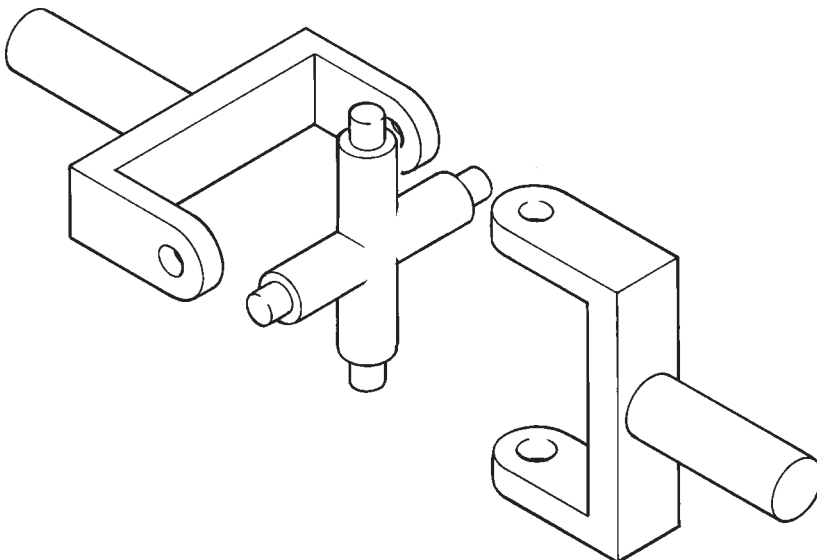


This type of joint uses flanges fixed onto the end of each shaft bolted together. Sometimes another disc is mounted between the flanges. If this disc is flexible, some small angular movement is possible. This arrangement is not very suitable for this particular design problem, as too much strain will be applied to the bolts and the flanges - damage would quickly occur.

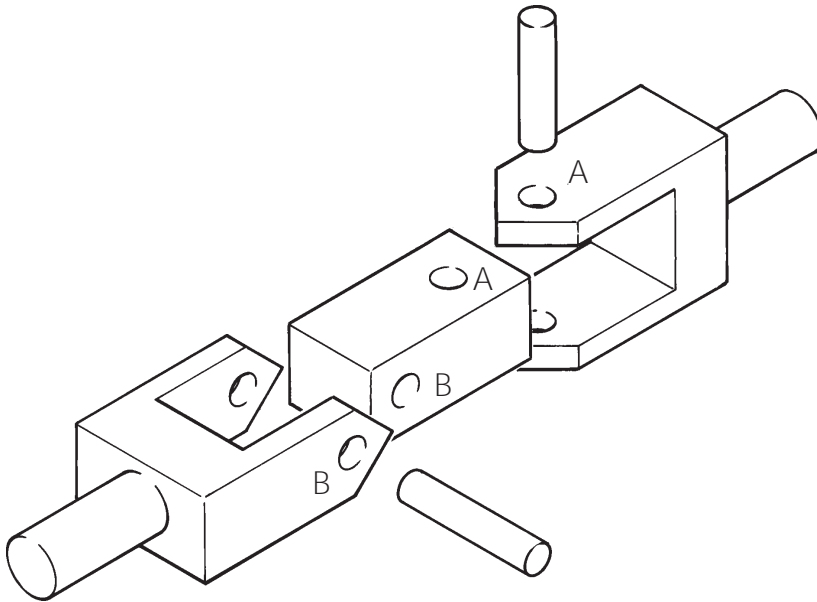
A slightly better arrangement is where the flanges are separately bolted onto the flexible disc.



This is not an ideal solution, as there is a limit to the angular movement. A better proposition would be the use of a **universal joint**. These joints allow a great range of movement, whilst allowing rotational motion to be maintained. A Hooke's type universal joint uses two forked yokes and a centre member.



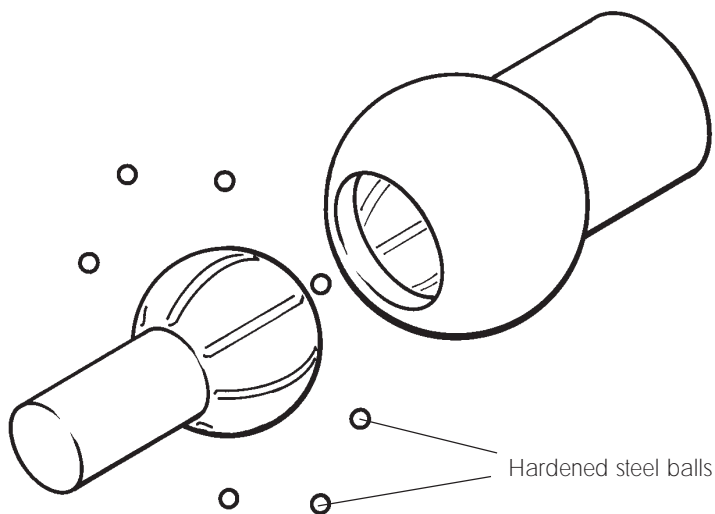
Movement is possible due to the forks being able to pivot around the central member. Many types of universal joints use similar geometry. Such a joint may be found as part of a socket spanner kit, with a central block with pins or bolts taking the place of the centre member.



On the diagram shown above, the holes labelled 'A' align, as do holes 'B'. Sometimes bearings are provided to reduce friction.

It is not feasible to make an exact copy of a universal joint using the facilities in school or college. It is possible, though, to consider an alternative design whilst using the same principles.

For large angles of deflection, a **constant velocity coupling** is used. This is a precisely ground cup with grooves, with a matching spherical insert.

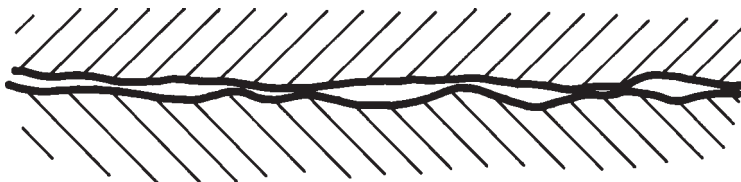


The balls transmit the motion and allow for very smooth movement at large angles of deflection.

The first stage in tackling this problem is to explore some ideas. An ideal way to do this is to model some possible solutions by using a technical construction kit such as *Fischer Technik*, *Lego Technic* or similar. A form of universal joint is available in both types of kit, although you should try out other solutions using components that are available.

## 2. SUPPORTING THE STEERING COLUMN AS IT ROTATES

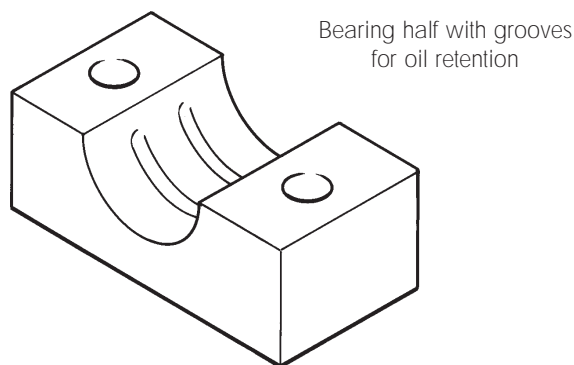
The steering column must be free to rotate when supported. When one surface comes into contact with another, friction is generated. Very few surfaces are truly smooth when magnified.



Magnified surfaces rubbing together

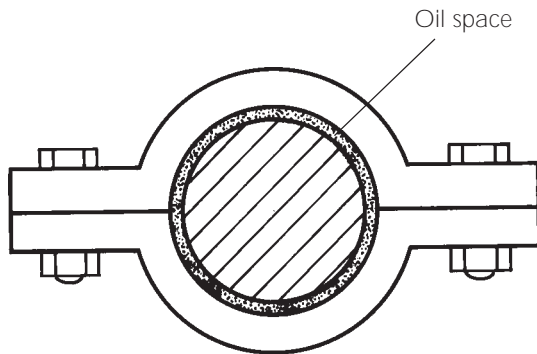
Rough surfaces moving over one another generate friction causing heat. This in turn may cause significant expansion of the component leading to jamming or seizure.

You will need to consider the effects of friction in your designs. Surfaces that rub together can be separated by a film of oil or grease. Where these are used, some way of keeping the lubricant in the joint would be needed.



Bearing half with grooves for oil retention

Oil or grease acting as a lubricant can prevent the surfaces touching and reduce the friction.



In the design of bearings, the following factors are crucial:

- a) the materials from which the bearing surfaces are made - their coefficients of friction.
- b) the area of the bearing surface. A large area will adequately support the shaft, but may lead to unnecessary friction being produced. A small area in which friction may not play a significant part may produce sufficient support.
- c) the type of lubricant used - its viscosity.

The viscosity of a lubricant may be described as its '**resistance to flow**'. Thin oils have a low viscosity and flow easily through small holes and clearances. Thick oils have a high viscosity and offer more resistance to flow or change of their shape. Thus they resist being squeezed out of bearing surfaces at high pressure. Oil is affected by temperature - it has a lower viscosity as it gets hotter.

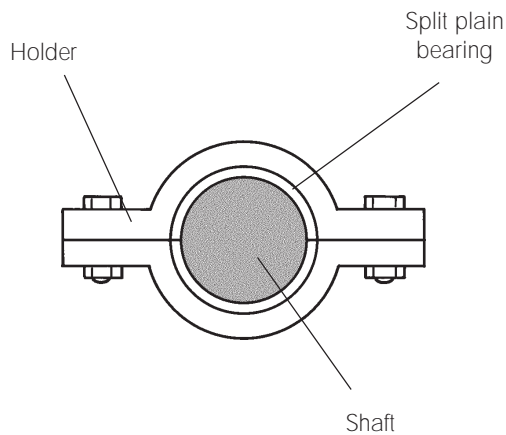
In America, the Society of Automotive Engineers (SAE) has established a means of classifying oils by their viscosity using numbers. Each SAE number defines the viscosity of the oil at a temperature of 99 degrees. For example:

SAE number	Oil thickness	Application
10	Extra-light	Typewriters, sewing machines
30	Medium	General lubrication
75-250	Extra heavy	Gears and transmissions

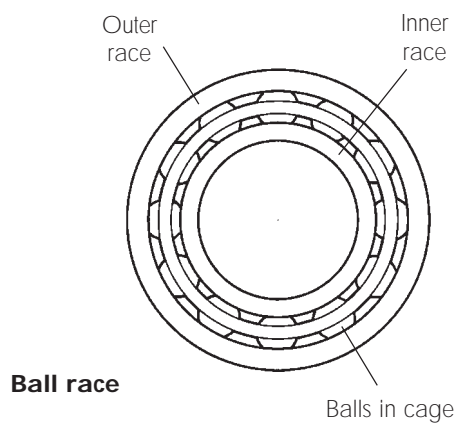
In addition **W numbers** are used to cover the effects of low temperatures, i.e., within a specified viscosity range at -18 degrees, also at 99 degrees - for example SAE20W. Many motor cars use multigrade oils with SAE numbers showing hot and cool viscosities, for example, SAE20/50W.

The friction between two pieces of oiled steel is quite low and would be suitable for a steering column. A small space between the bearing and the column is needed for the lubricant when the bearing block is designed and made. This is known as a **clearance fit** and might be as much as 0.5 mm more than the shaft size.

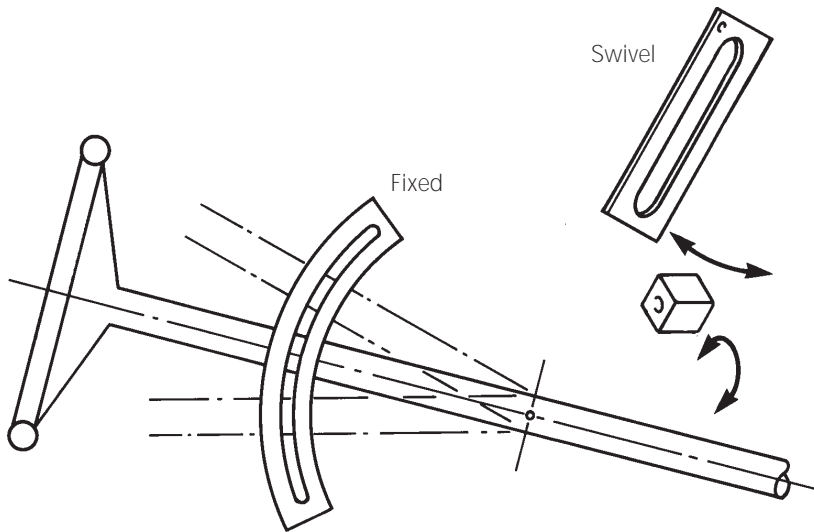
Friction can be reduced by using a bush or a bearing - a bush is another piece of material used in between the two surfaces. A plain bearing can be made from nylon, cast iron, brass or aluminium. Some materials such as nylon and special bearing metals do not need lubrication. Some plain bearings are made in two halves for ease of assembly.



Ball and roller races can also be used - these are a series of caged balls or rollers. These types of bearings can take considerable forces and greatly reduce friction. The ball or roller elements are housed in precisely made tracks and cages. They can also be supplied with the lubricant sealed in.



The next stage in the task is to consider the design of suitable brackets that will accommodate the range of adjustment. You will need to explore the shape requirements for such brackets, together with the material(s) they might be manufactured from. Some initial ideas might include the following:



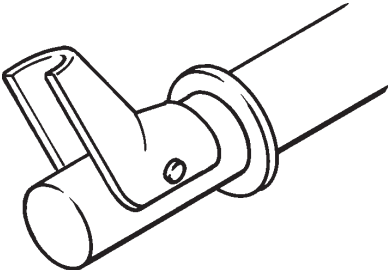
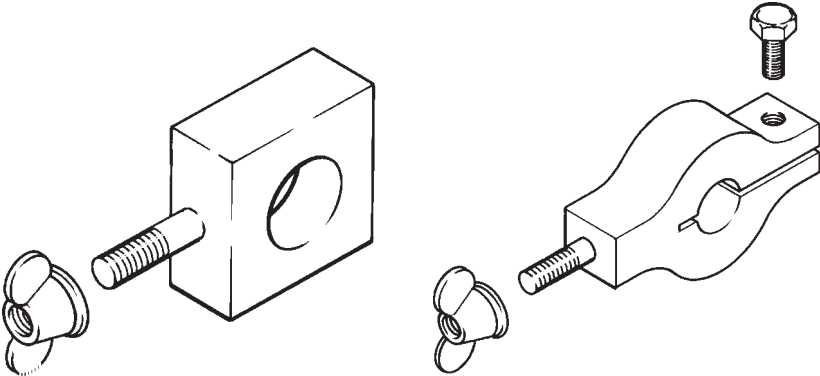
Shaft support needs to rotate slightly if bracket is straight. It can be fixed if bracket slot at the correct radius or bracket is capable of movement

Following are some suggestions for brackets that will both support the column and allow it to be adjusted. You may decide to choose one of these options, or design one yourself.

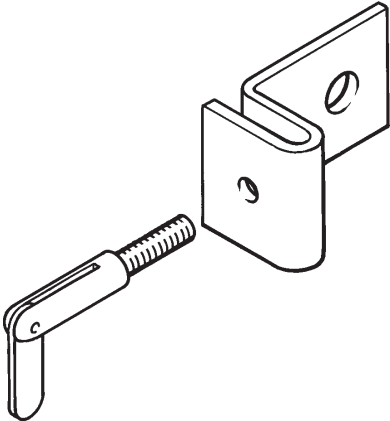
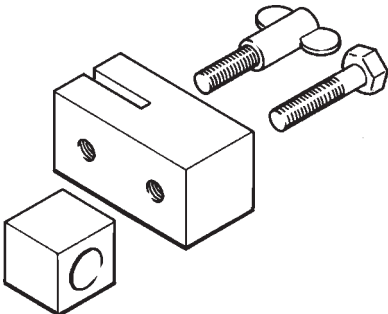
Your proposal should consider the machinery and equipment available to you and the expertise to operate it, to manufacture the bracket to the required level of quality.

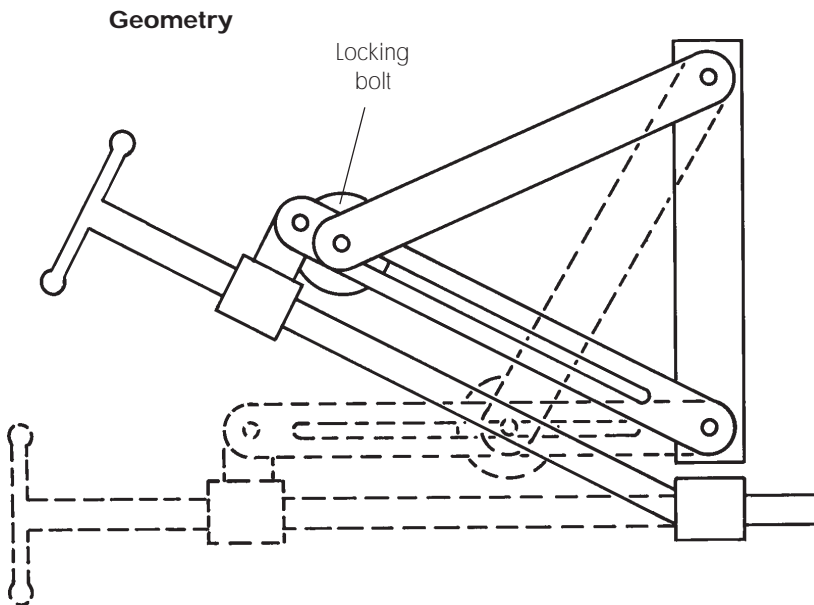
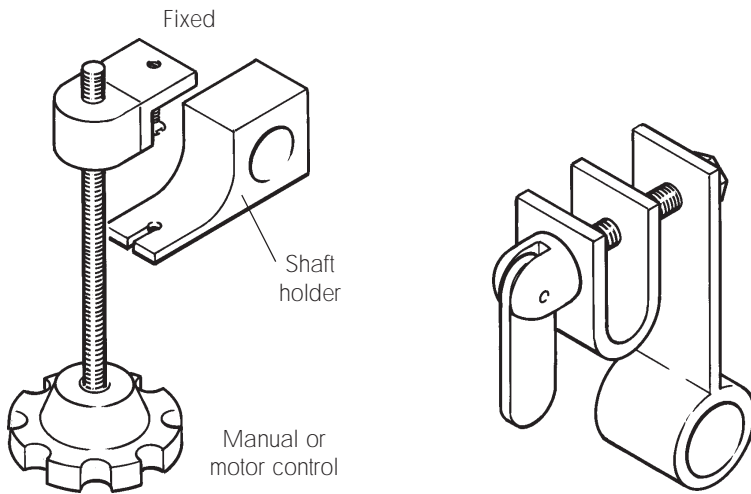
You may decide to inform your designing by examining the range of adjustment and locking devices currently available on motor cars. Most manufacturers or car showrooms will provide you with this information.

**Support brackets**



Screw threads or cams?  
Smooth or notched track?





The design of brackets will also be influenced by the type of **control system** used to adjust the rake of the steering wheel. You may decide it is appropriate to use *mechanical means*, by simply using the driver of the car to raise or lower the wheel. There are other alternatives which include *electro-mechanical or hydraulic* systems.

Whatever system you decide, the main design considerations are:

- a) the adjustment needs to be easily and accurately achieved
- b) the system needs held safely and securely in place
- c) the system should be reliable, only operating when required to do so.

### EVALUATING YOUR ADJUSTABLE STEERING COLUMN

1. Does the unit meet your original specification for the product? Consider all the points you listed originally.
2. Is it possible to gather some 'expert evaluation' of your steering unit - by contacting local motoring organisations perhaps?
3. Is it possible to identify accurately the costs involved in designing, making and assembly your unit.
4. Does the product meet the appropriate level of quality? If not, what changes do you need to consider during the manufacture and assembly of parts in order for this level to be attained?

