User's guide for MT-TWINGO

Study of Front and Rear Axle Assemblies Adjustable Chassis

EXOTEST® EDUCATION

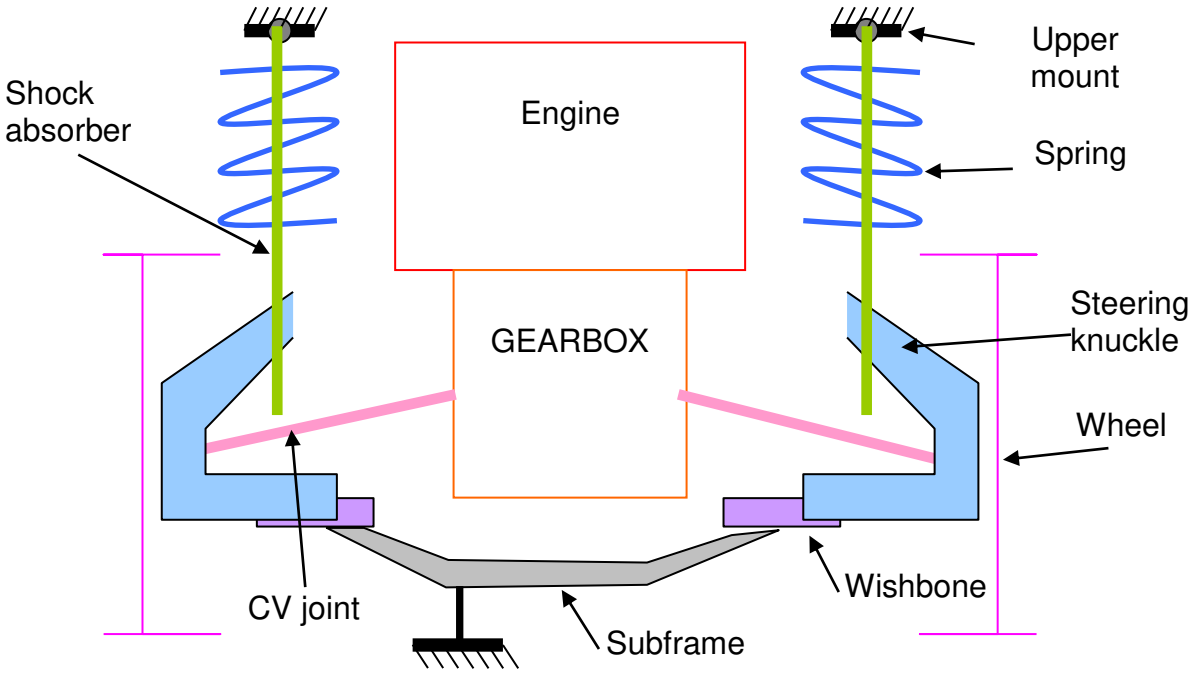
Document No 00312458-v1

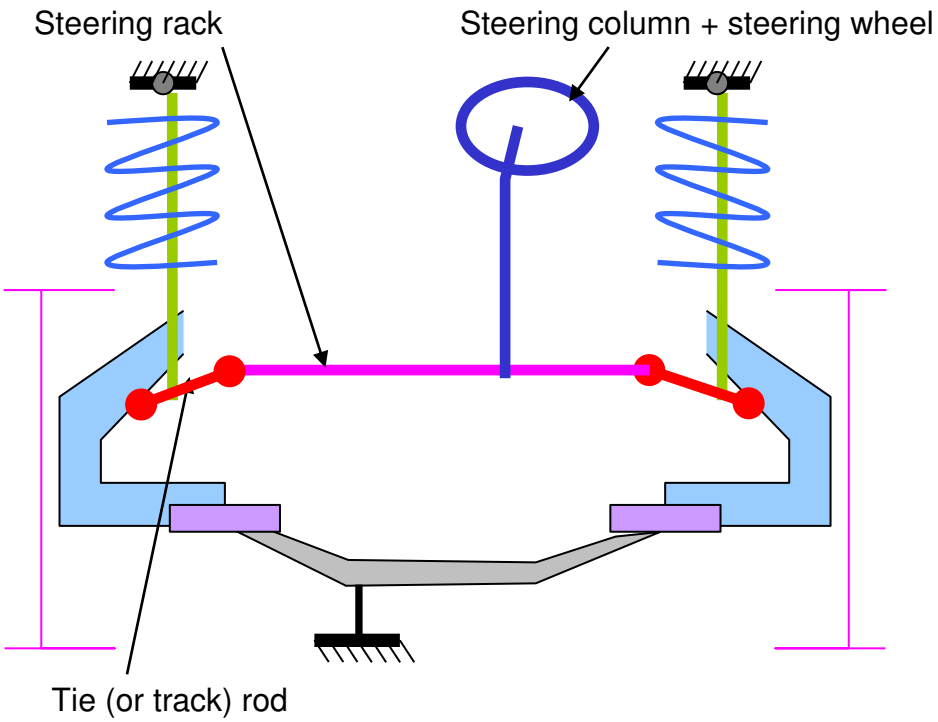
1. RESOURCES FILE

1.1. RUNNING GEAR – Part 1 -

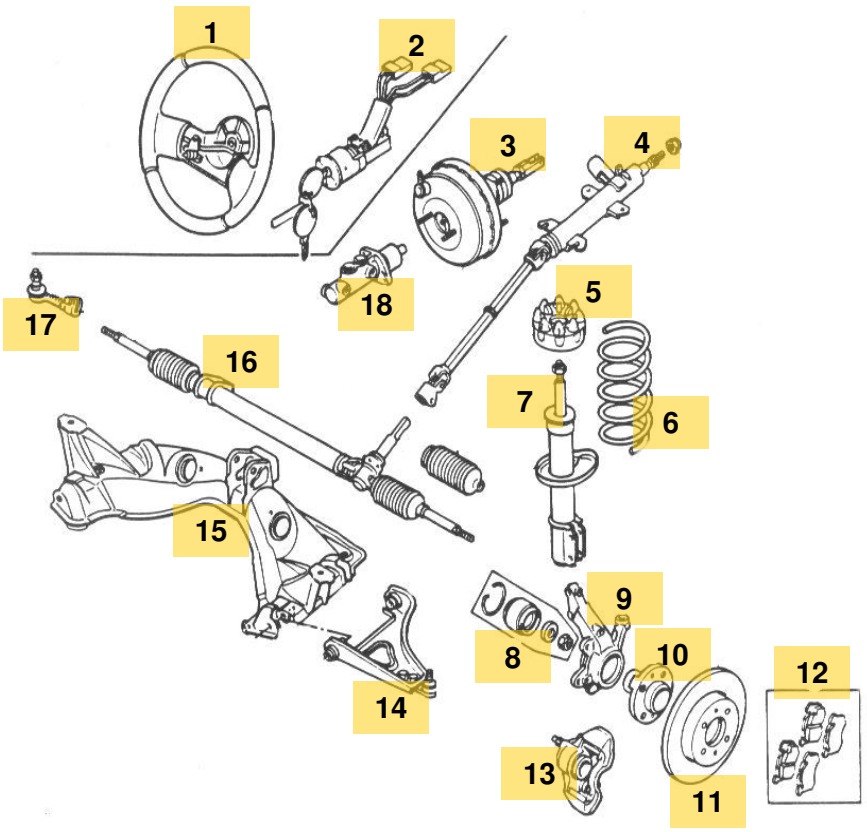
1.1.1. Purpose of this part

This section explains how to identify and name the various components of the running gear both on the vehicle and on a diagram and indicates the measurements necessary.





Exploded view of front axle assembly components

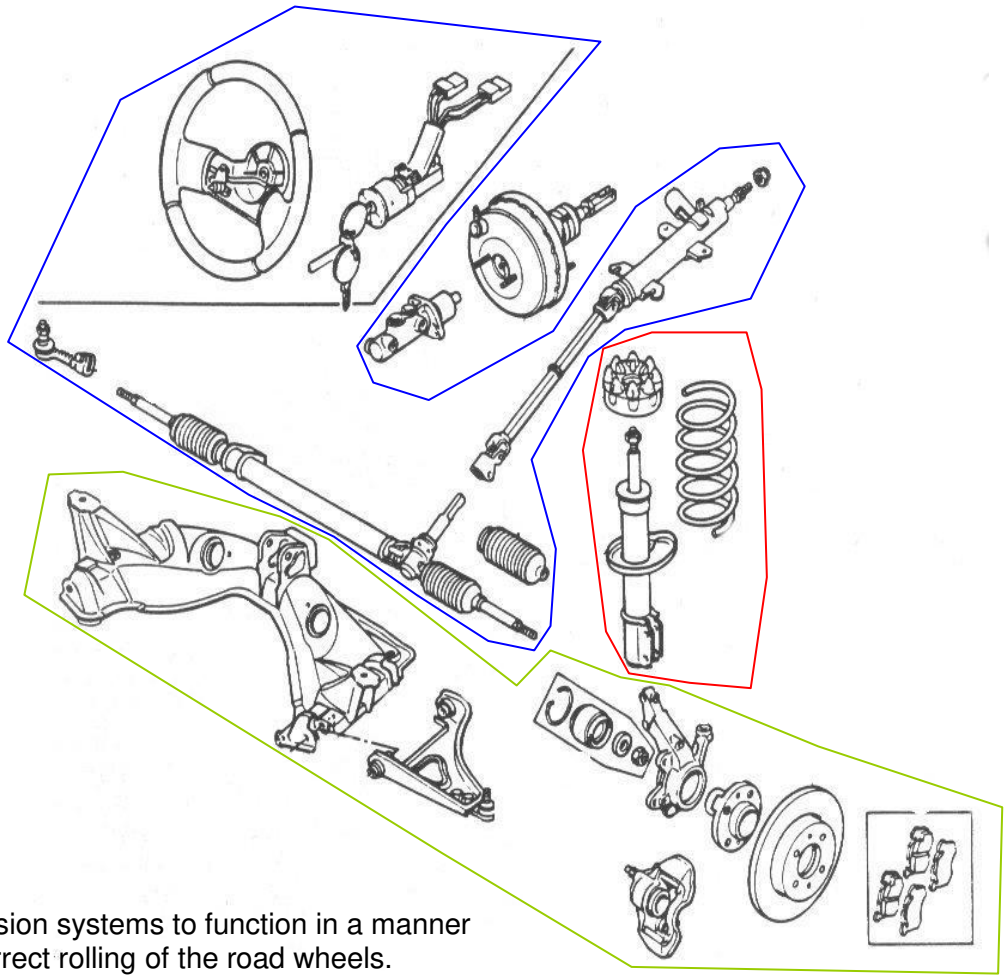


	FRONT AXLE ASSEMBLY
1	*Steering wheel*
2	*Ignition switch*
3	*Brake servo (brake booster)*
4	*Steering column*
5	*Front shock mounts*
6	*Suspension spring*
7	*Front shock absorber*
8	*Front wheel bearing*
9	*Front steering knuckle (or hub carrier)*
10	*Hub*
11	*Brake disk*
12	*Brake pads*
13	*Brake callipers*
14	*Lower wishbone*
15	*Subframe*
16	*Steering rack*
17	*Tie rod end*
18	*Brake master cylinder*

Exploded view of rear axle assembly components

	REAR AXLE ASSEMBLY
19	*Handbrake lever*
20	*Handbrake cable*
21	*Brake drum*
22	*Road wheel*
23	*Hubcap*
24	*Rear wheel bearing*
25	*Rear stub axle*
26	*Rear suspension spring*
27	*Rear axle*
28	*Rear shock absorber*

1.1.2. Subassemblies



Suspension system

This system consists of a spring and a shock absorber. It provides a smooth ride when travelling over uneven road surfaces and damps out high-frequency oscillations for enhanced passenger comfort.

Steering system

Turns the wheels to steer in the direction required by the driver.

Interface with ground system

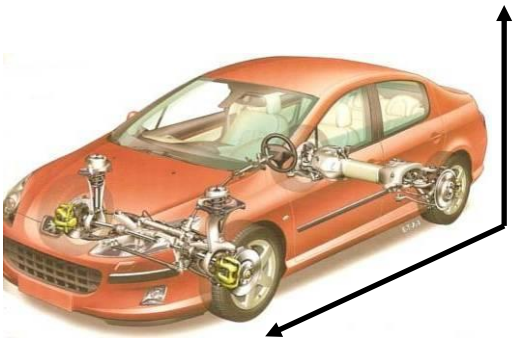
Allows the steering and suspension systems to function in a manner which is compatible with the correct rolling of the road wheels.

Tyres

Provide the only points of contact between the vehicle and the road, and adherence to the road surface. The tyres also transmit the driving and braking torque to the ground and absorb lateral forces of all types.

These subassemblies form, depending on the specific configuration, either a half-axle, or an axle: they have different functions and these subassemblies are mechanically linked to each another.

1.1.3. Functions of the front and rear axle assemblies



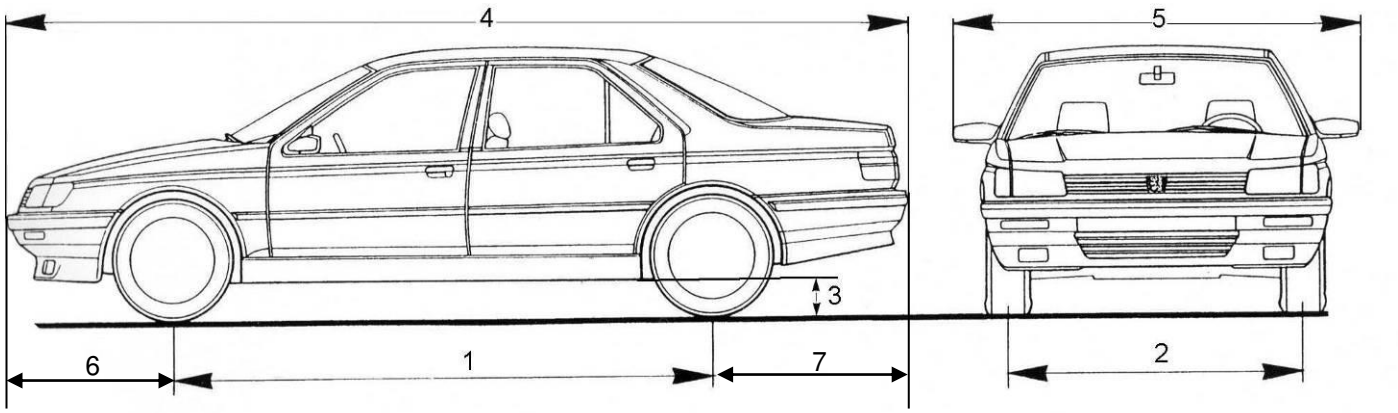
- Keep the vehicle travelling in the required direction
- Absorb unevenness in the road
- Reduce the rolling resistance

They contribute to road safety, comfort and fuel economy.

The correct geometrical orientation of the wheels is extremely important.

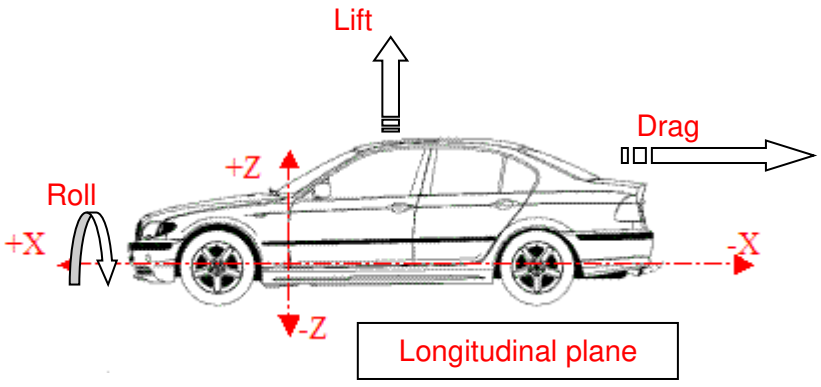
Any misalignment causes impaired road holding and/or abnormal tyre wear.

1.1.4. Vehicle dimensions

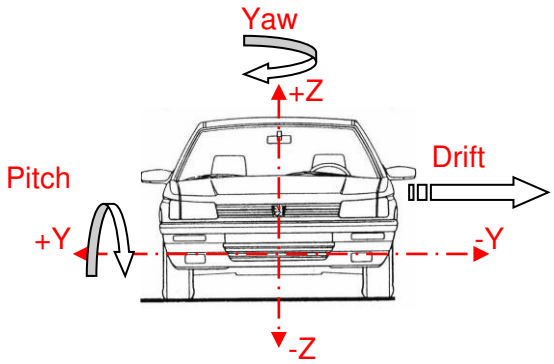


1	Wheelbase
2	Track (width)
3	Ground clearance
4	Overall length
5	Overall width
6	Front overhang
7	Rear overhang

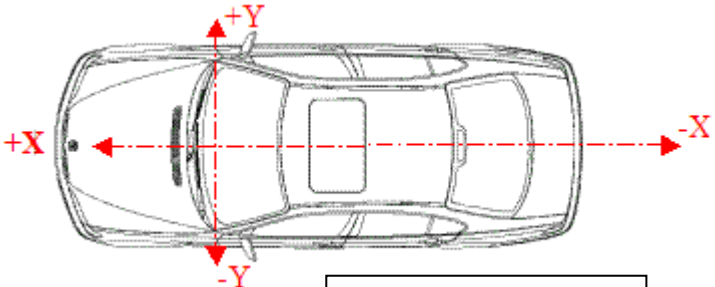
1.1.5. Spatial axes of movement and dynamic forces



Longitudinal plane

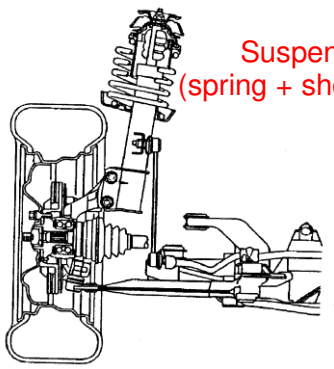


Transverse plane



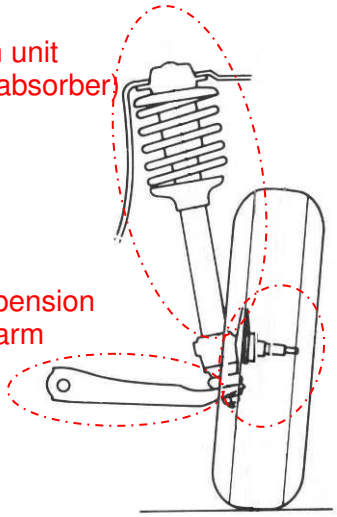
Horizontal plane

1.1.6. The three most common design principles



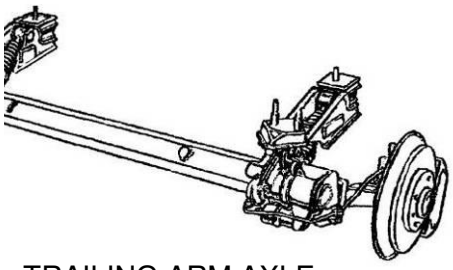
Suspension unit (spring + shock absorber)

Suspension arm

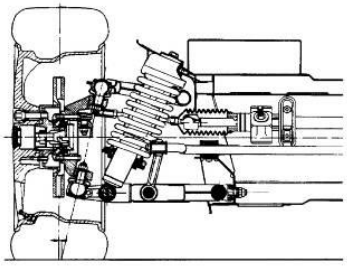


Hub carrier

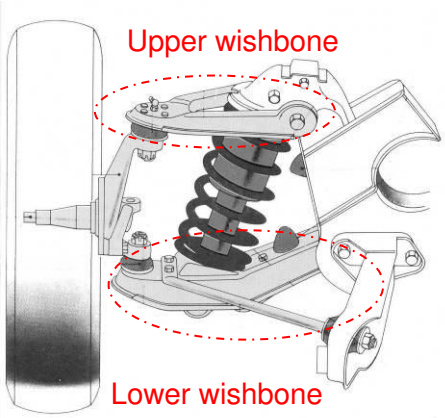
PSEUDO MACPHERSON



TRAILING ARM AXLE

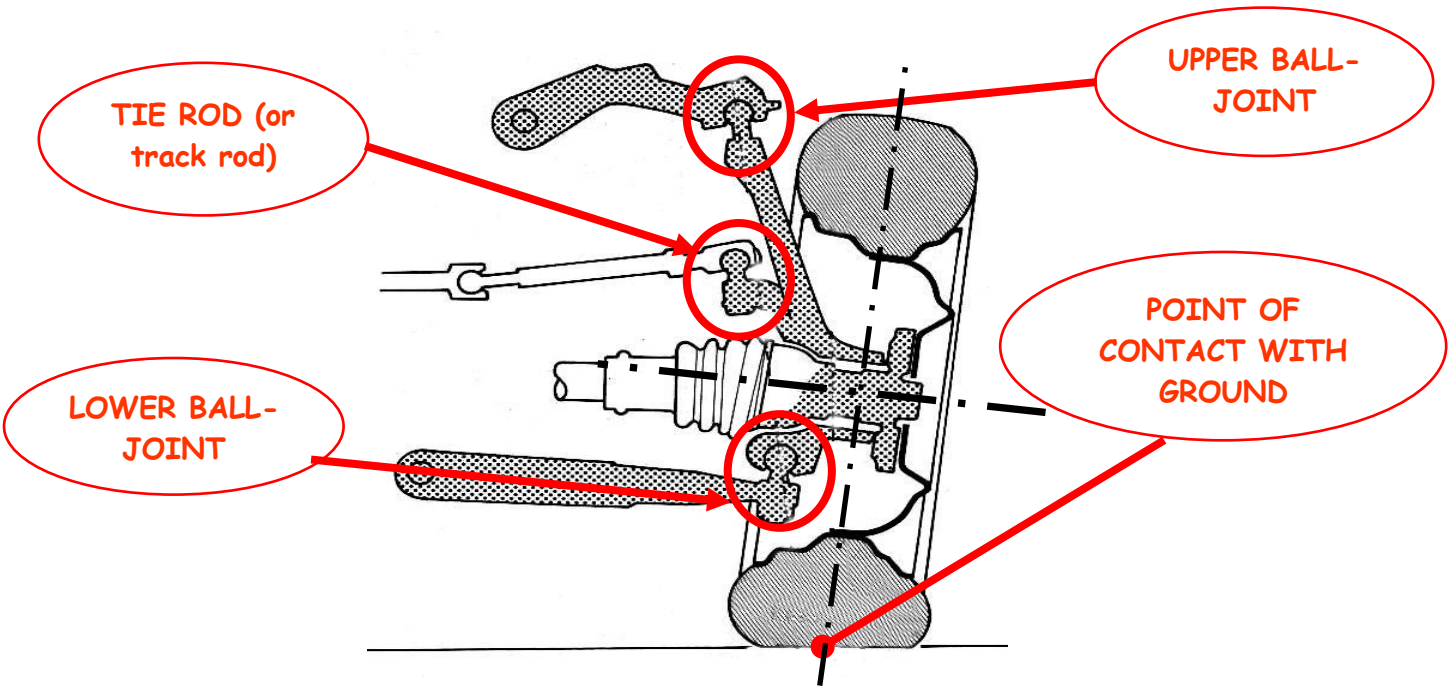


DOUBLE WISHBONE (PARALLELOGRAM)



Upper wishbone

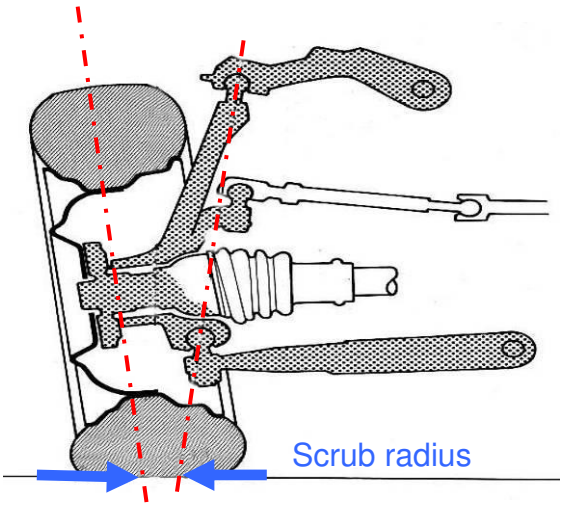
Lower wishbone

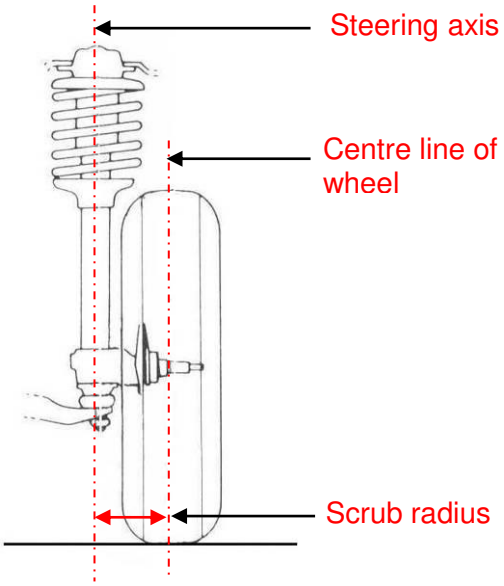


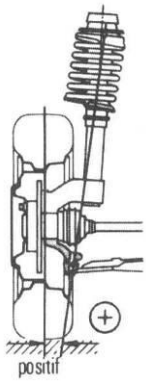
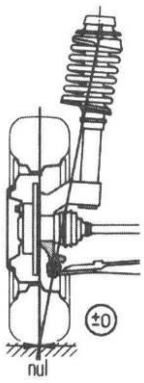
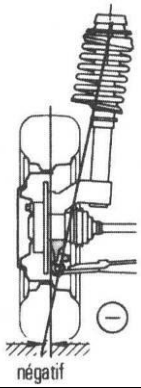
THE 4 KEY POINTS

1.1.7. Scrub radius

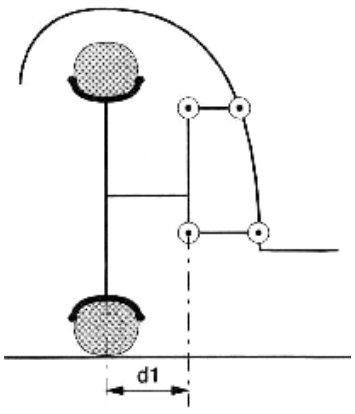
The scrub radius is distance between the centre line of the wheel (through the point of contact with the road) and the projection of the steering axis.



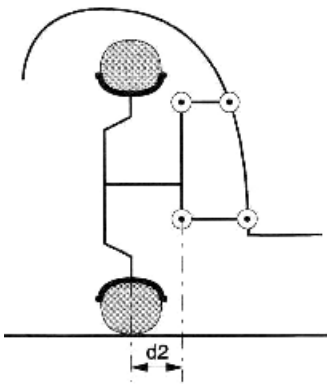


		
Positive scrub radius	Zero scrub radius	Negative scrub radius

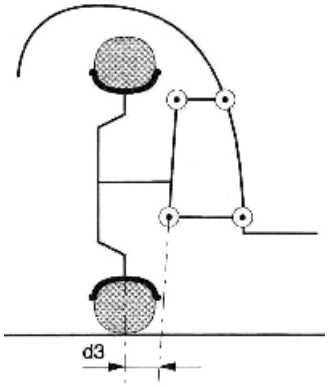
Solutions for reducing the scrub radius



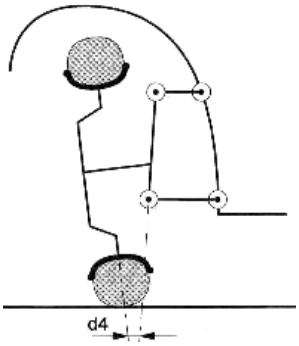
Theoretical scrub radius



Reduction of the scrub radius by rim inset



Reduction of the scrub radius by rim inset and steering axis inclination



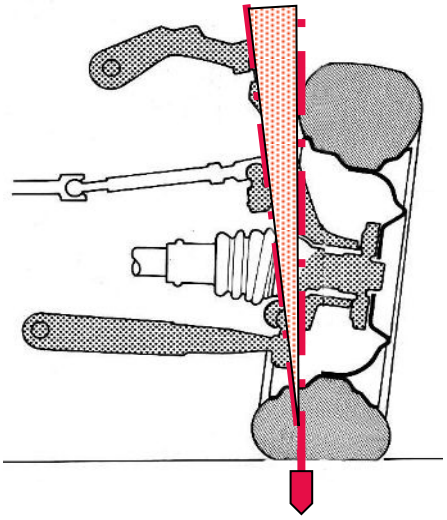
Reduction of the scrub radius by rim inset, steering axis inclination and camber modification

1.2. RUNNING GEAR – Part 2 -

1.2.1. Purpose of this part

This section explains how to identify the various characteristic angles of running gear so that the trainee can, after checking the wheel alignment geometry, evaluate the conformity of the positioning. The trainee will then be able to identify these angles on the vehicle and on a diagram.

1.2.2. Steering axis inclination ⇒ SAI

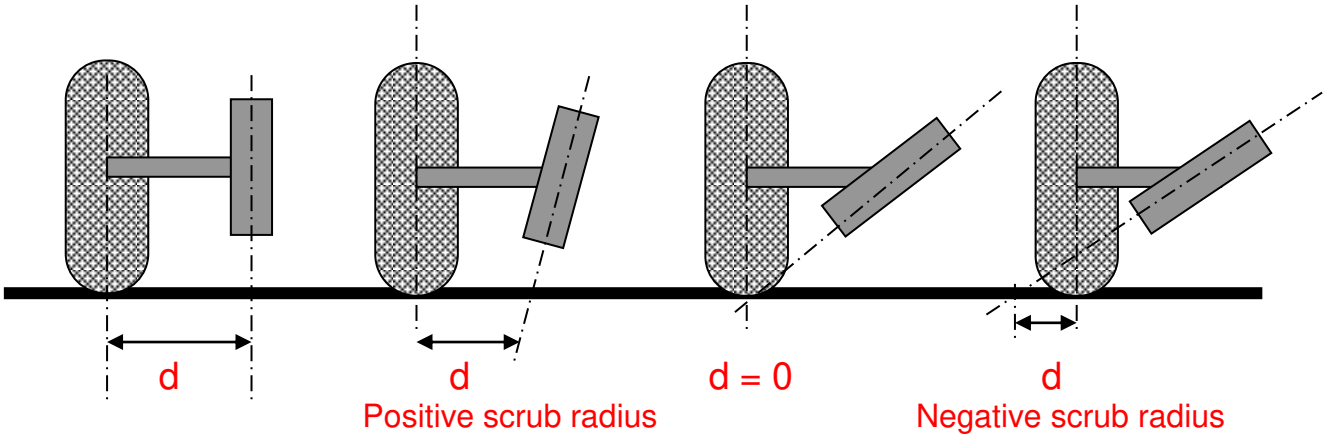


Definition

Steering axis inclination (SAI) is the angle formed by a line running through the upper and lower ball joints (the steering axis) and the true vertical to the ground, looking from the front of the vehicle.

Functions

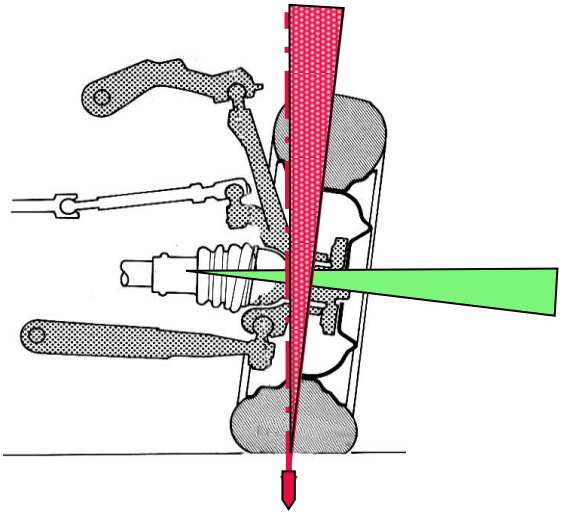
Reduces or eliminates the scrub radius and gives the system a greater ability to self-centre (i.e. to return to the straight ahead position).



The effects induced by an incorrect steering axis inclination:

STEERING AXIS INCLINATION	INSUFFICIENT	Not enough self-centring at low speed.
	TOO HIGH	Steering too hard and too much self-centring.
	UNEVENLY DISTRIBUTED	The vehicle pulls to the side where the angle is smallest, scrub radius is produced when braking and steering is unstable.

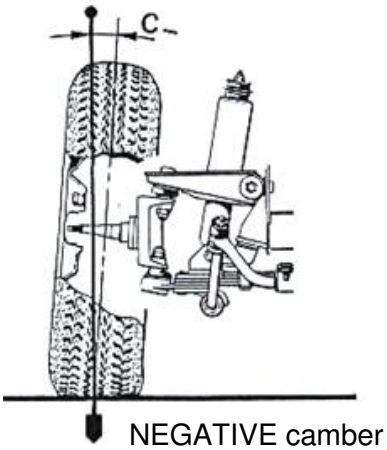
1.2.3. Camber ⇒ Ca



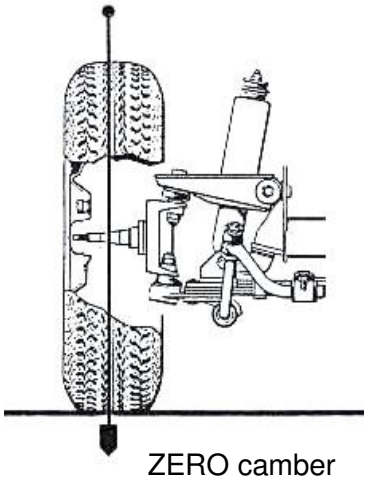
Definition

Camber is the angle formed by the centre line of the wheel and the true vertical to the ground. The same angle can be defined as being the angle formed by the axis of the hub carrier and the horizontal, when viewed from the front of the vehicle. It is thus the tilt of the wheel away from the vertical.

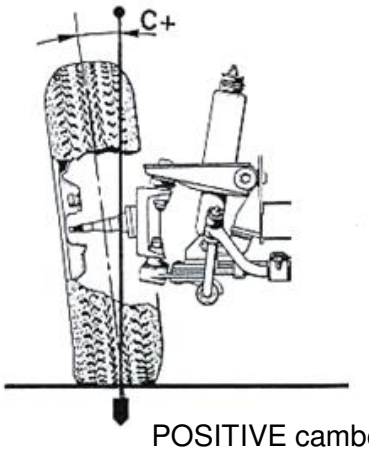
The camber, which is always very small, may be positive, negative or zero.



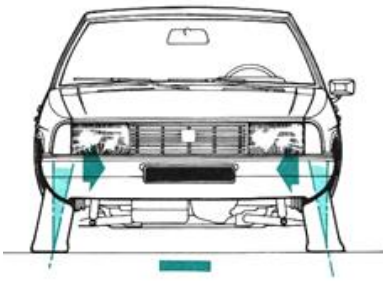
NEGATIVE camber

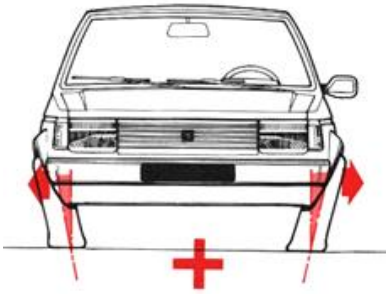


ZERO camber



POSITIVE camber



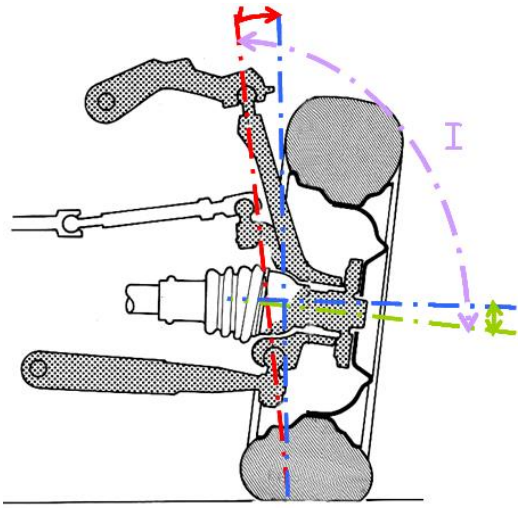


Functions

Reduces the scrub radius, thus limits the reaction from road unevenness or bumps being transmitted back to the steering wheel. Consequently, it thus reduces the wear on the mechanical parts. Absorbs the forces generated by any obstacles on the road.

CAMBER	POSITIVE	- Tire wear on the outside of the tread width. - Poor road holding.
	NEGATIVE	- Tyre wear on the inside of the tread width. - Better road holding. - Instability when braking.
	UNEVENLY DISTRIBUTED	- Pulls the vehicle to one side or the other.

1.2.4. Included angle ⇒ I



Definition

The included angle is the angle between the steering axis and the axis of the hub carrier. It is equal to the sum of the SAI and the camber angle + 90 °.

The included angle can be expressed in two ways:

- I = Ca + SAI + 90° where Ca is measured with respect to the horizontal.
- I = Ca + SAI where Ca is measured with respect to the vertical.

Function

It sets the geometry of the steering knuckle (or hub carrier)
It makes it possible to identify which part is distorted or deformed (e.g. axle or hub carrier).
NB: The included angle must be the same for the two wheels on the same axle. (In practice a tolerance of + or – 1° is permissible).

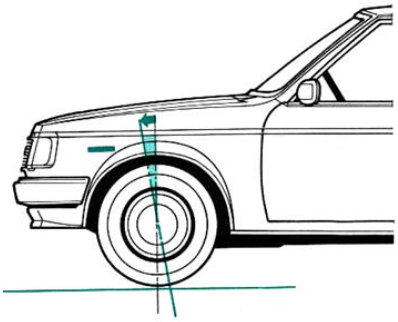
INCLUDED ANGLE	UNEVENLY DISTRIBUTED FROM RIGHT TO LEFT	Distorted or deformed steering knuckle Deformed half-axle element

1.2.5. Caster angle ⇒ Ch

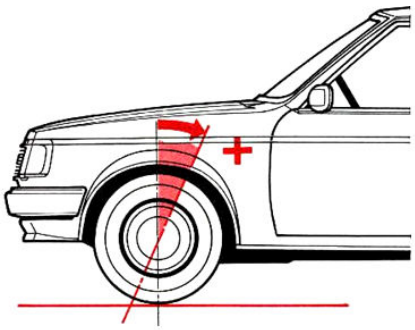
Definition

The caster angle is the angle formed by a line running through the upper and lower ball joints (the steering axis) and the true vertical to the ground, looking from the side of the vehicle.

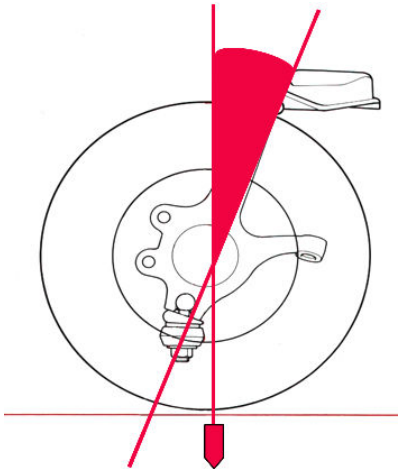
The caster angle can be positive or negative.

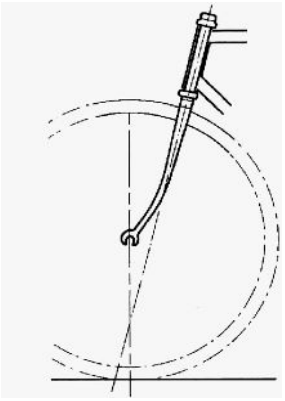


The caster angle is negative when the upper ball joint is inclined forward



The caster angle is positive when the upper ball joint is inclined backward



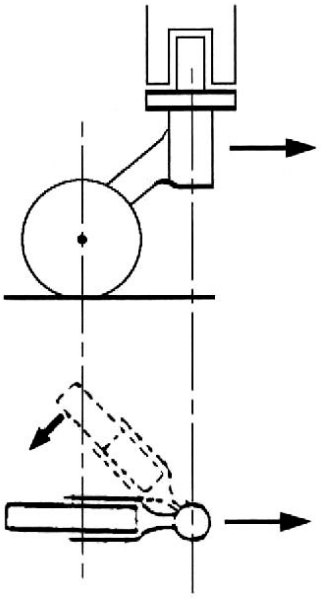


Functions

Self-centres the wheel (to straight ahead) after steering in a particular direction, and maintains them there. Provides auto-stability for the vehicle.
NB: the degree of self-centring is proportional to the speed and to the caster angle.

The effects induced by a caster angle fault

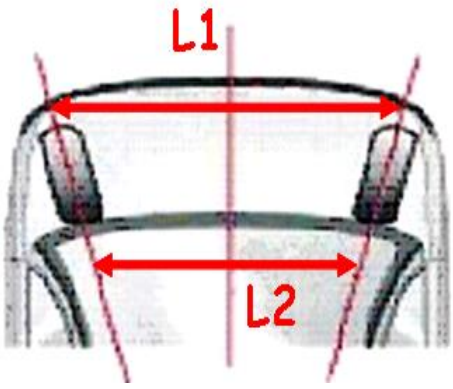
CASTER ANGLE	TOO HIGH	Makes the steering hard and unstable when cornering Too much wheel self-centring.
	INSUFFICIENT	Not enough self-centring Causes insufficient steering stability
	UNEVENLY DISTRIBUTED	Results in pulling on the side where the angle is smallest in addition to steering instability.



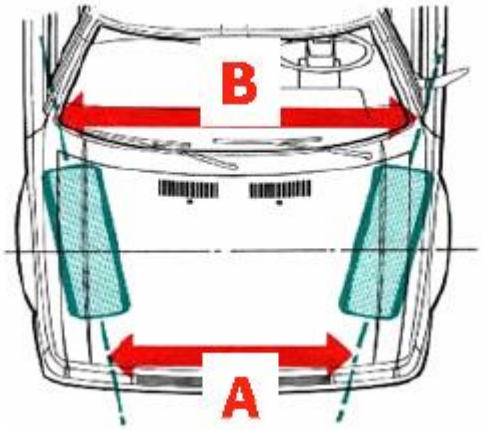
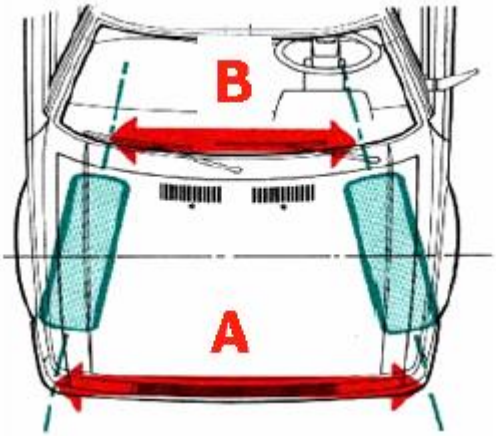
1.2.6. Parallelism (toe in/out) ⇒ Pa

Definition

Parallelism, often called “toe”, is the difference in the distance between the fronts of the two wheels (L1) and rears of the two wheels (L2) on the same axle at the same height as the hub carrier. The unit of measurement is the millimetre (mm).



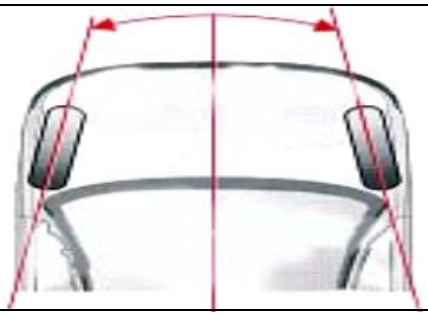
Parallelism may be:

Positive if A < B, which is referred to as "toe-in".	
Negative if A > B, which is referred to as "toe-out".	

Functions

- Stabilises the vehicle when travelling straight ahead and avoids abnormal tyre wear.
- Corrects the effects of camber and scrub radius.
- Compensates for the effects induced by the thrust (on rear-wheel drive vehicles) or pull (on front-wheel drive vehicles)

Toe in/out can be expressed in two different ways:

① As the angle formed by the longitudinal axis, or the axis of symmetry, of the vehicle and the centre line of a wheel. In this case it is measured in degrees and minutes (°.').	

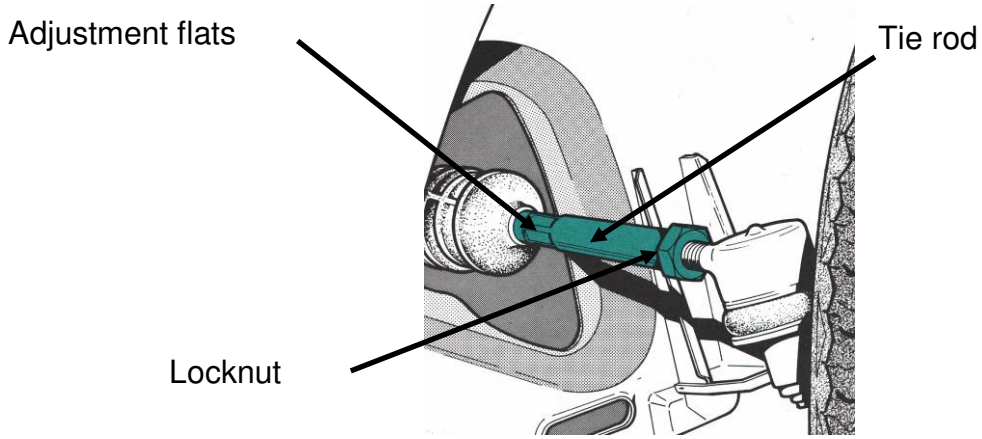
As the difference in the distance between the front ②and rear of the wheels on the same axle at the height of the hub carrier. In this case it is measured in millimetres (mm).	

The effects induced by a parallelism fault:

PARALLELISM	TOO MUCH TOE-IN	Causes significant wear of the outside of the tyre.
	TOO MUCH TOE-OUT	Causes significant wear of the inside of the tyre.
	UNEVENLY DISTRIBUTED	Pulls the vehicle – Tyre wear.

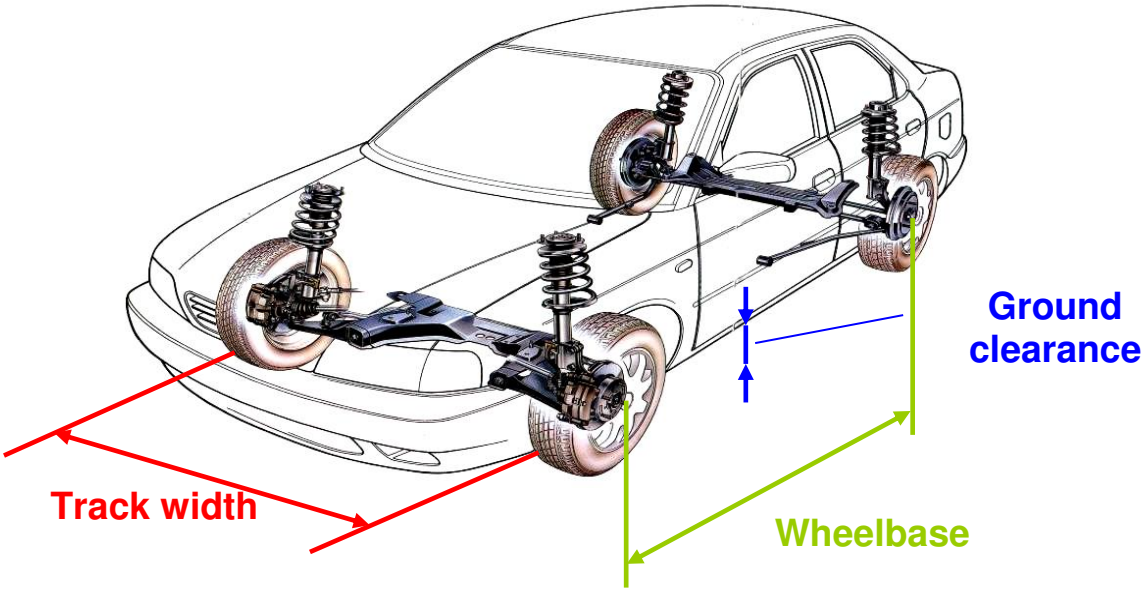
1.2.7. Adjusting the parallelism

On modern vehicles, the parallelism is more or less the only variable which can be adjusted. The adjustment is made by screwing in or out the tie rod (also known as the track rod) which connects to the ball joint. This action on the tie rod shortens or lengthens the assembly, and in so doing adjusts the parallelism.



1.2.8. Dimensional characteristics

Three of the key vehicle dimensions specifically relate to the running gear:

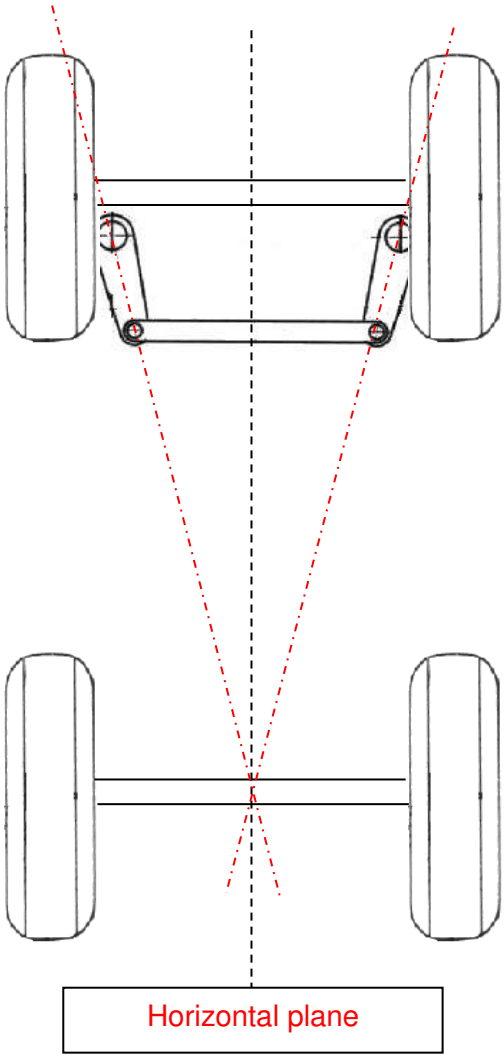


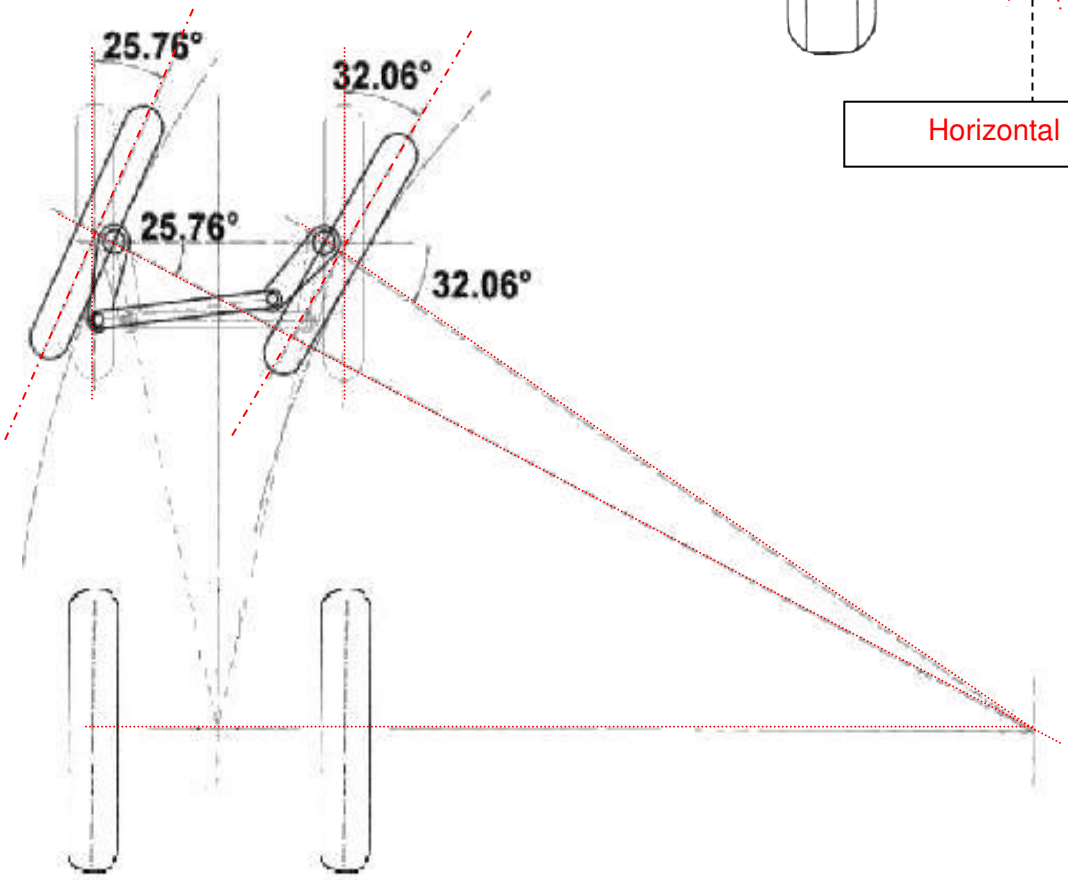
1.2.9. Ackerman steering geometry

Definition

The Ackerman steering geometry produces different steering angles for the front wheels on the inside and outside of the turn to avoid scrubbing the tyres when cornering.

To achieve this, the lines through the steering arms must intersect at the centre of the rear axle assembly.





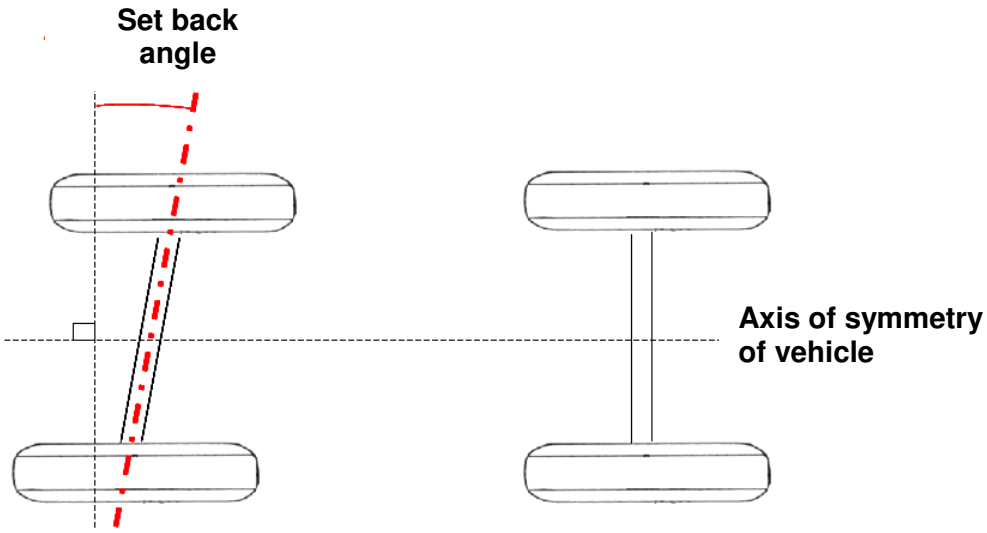
1.2.10. Set back

Definition

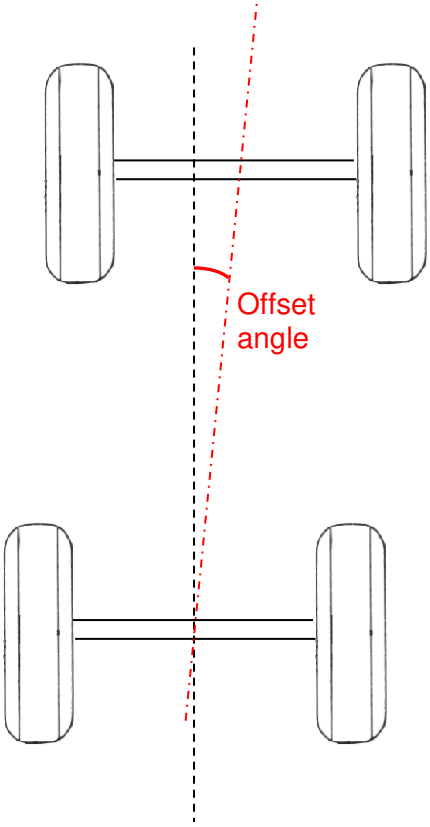
Set back is the longitudinal offset of the wheels on the same axle. It is caused by a fault with the half-axle or chassis.

Set back angle

This is the angle formed by the straight line passing through the centre of the two wheels on the same axle and the perpendicular to the axis of symmetry.



1.2.11. Offset angle



Definitions

- **Offset:** the lateral deviation of one axle with respect to the other. It is caused by an axle alignment fault or a chassis fault.

- **Offset angle:** the angle formed by the straight line passing through the middle of the two axles and the axis of symmetry of the vehicle.

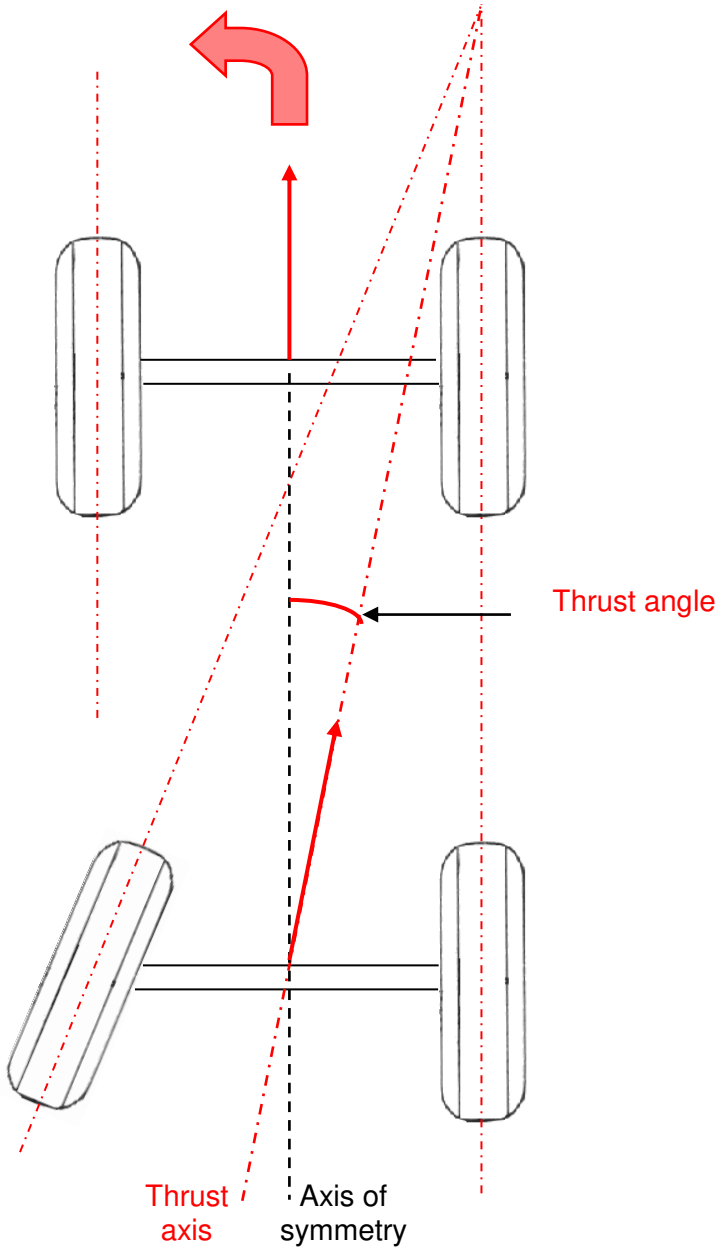
1.2.12. Thrust angle

Definitions

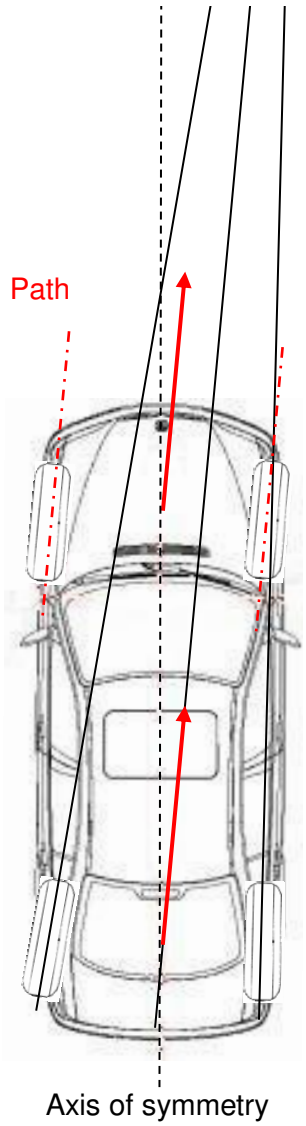
Thrust axis: the axis which passes through the middle of the rear axle and continues to the point where it meets the extension of the centre lines of the rear wheels. This axis corresponds to the path which the rear axle assembly would follow if it could move by itself. If the thrust axis points to the right of the vehicle, then the vehicle will turn to the left. To neutralise this effect, the driver must steer towards the right, so that the front wheels are parallel to the thrust angle. The vehicle then drives in a crab-wise manner (yawing).

Thrust angle: this is the angle formed between the thrust axis and the axis of symmetry of the vehicle. It is caused by a parallelism fault at the rear axle. This angle should theoretically be zero.

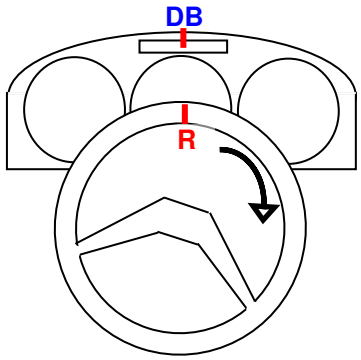
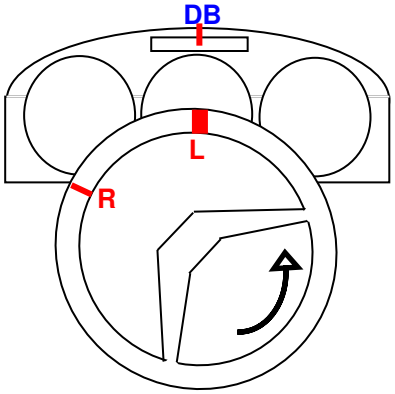
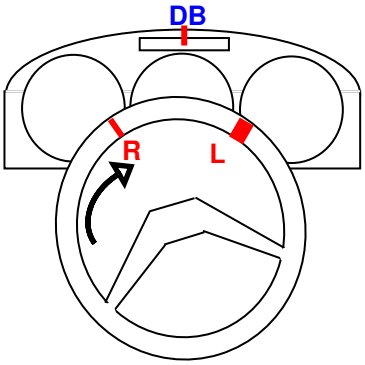
Disadvantage: this problem affects the Ackerman steering geometry, which does not perform its functions correctly.



The vehicle "crabs" or yaws



1.2.13. Procedure for setting the steering in its straight-ahead position

Phase	Operations	Tools	Diagrams
100	**Steer to the right**	White chalk	
101	Turn the steering wheel to its right full-lock position		
102	Draw a mark “R” on the highest point of the steering wheel		
103	Draw a mark “DB” on the dashboard aligned with the “D” mark on the steering wheel.		
200	**Steer to the left**	White chalk	
201	Turn the steering wheel all the way to its left full-lock position, counting the number of turns.		
202	Draw a mark “L” on the highest point of the steering wheel aligned with the “DB” mark.		
300	**Set steering wheel in straight-ahead position**		
301	Turn the steering while to the right through half the number of turns counted previously.		
302	Adjust the wheel so that the marks “R” and “L” are equidistant from the mark ”DB”.		
303	Engage the steering wheel lock (the steering is centred, but the steering wheel may not be).		
400	**Centring the arms of the steering wheel** (If they are not already centred)	Manufacturer’s manual Standard tools	**Caution: Do not touch the steering wheel if it is fitted with an airbag!**
401	Remove the steering wheel from the steering column by following the instructions in the manufacturer’s manual		
402	Refit the steering wheel to the steering column with its arms centrally positioned.		
403	Tighten to the correct torque and replace the covers.		

2. USER FILE

2.1. USER MANUAL AND INSTRUCTION MANUAL

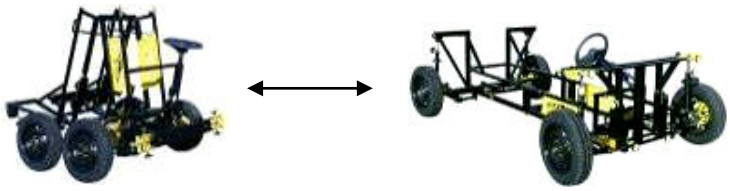
Delivery and Handling

The chassis is delivered, film-wrapped, on a pallet. The brakes on the 4 wheels are in their locked-on position.

You are responsible for dismantling the pallet and removing the chassis. Clear an open area with plenty of space in which to work.

Remove all the plastic film-wrapping.		Using an electric screwdriver, remove the pallet's two upper side members.	
Then remove one of the large panels on one side.		Using a utility knife or pliers, cut the 4 straps securing the wheels.	
Unlock the 2 rear brakes.		Unlock the 2 front brakes.	
The chassis is secured in a closed position. It will not open by itself.		Hold the 2 handles and pull the chassis off and away from the pallet. You can now dispose of the rest of the pallet.	

Folding up and unfolding the chassis



⚠ The trainer is the only person authorised to fold-up or unfold the chassis, and no trainee should be nearby.

Limit on use: This model is not a vehicle; you must not sit in or stand on it to move around.

Unfolding or opening the chassis

Clear a suitable space, about 4 meters square.

Check that the chassis is locked.		Place the chassis such that its rear wheels are where you would like them to be once the chassis is unfolded. Lock the rear wheels.	
Release the locking feature.		Allow the chassis to slowly unfold, controlling the movement by holding the handle at the model's centre.	
Damper gas springs assist the opening of the chassis by preventing it from opening suddenly and damaging the equipment.			
Lock the chassis in its open configuration.		➔	

The chassis may be used by the trainees in an area designated for the study of running gear.
The measurements are made on the chassis in the same way as they are made on a road vehicle.

Folding-up or closing the chassis

Clear a suitable space, about 4 meters square.

The chassis is open and locked. Lock the rear wheels.		Release the locking feature and stand on the same side as this feature.	
Hold the handle & the support under the steering wheel. As you lift gently, walk towards rear of the chassis.		The chassis will start to fold up.	
The chassis is folded up.		Insert the pin to lock the chassis in its folded up position.	

The chassis may be stored in its storage area.

Moving the chassis
Check that the 4 wheels are unlocked.

Moving the folded-up chassis: using the two handles at the rear, push to go straight ahead, and to turn lift the rear slightly to skid the chassis round.

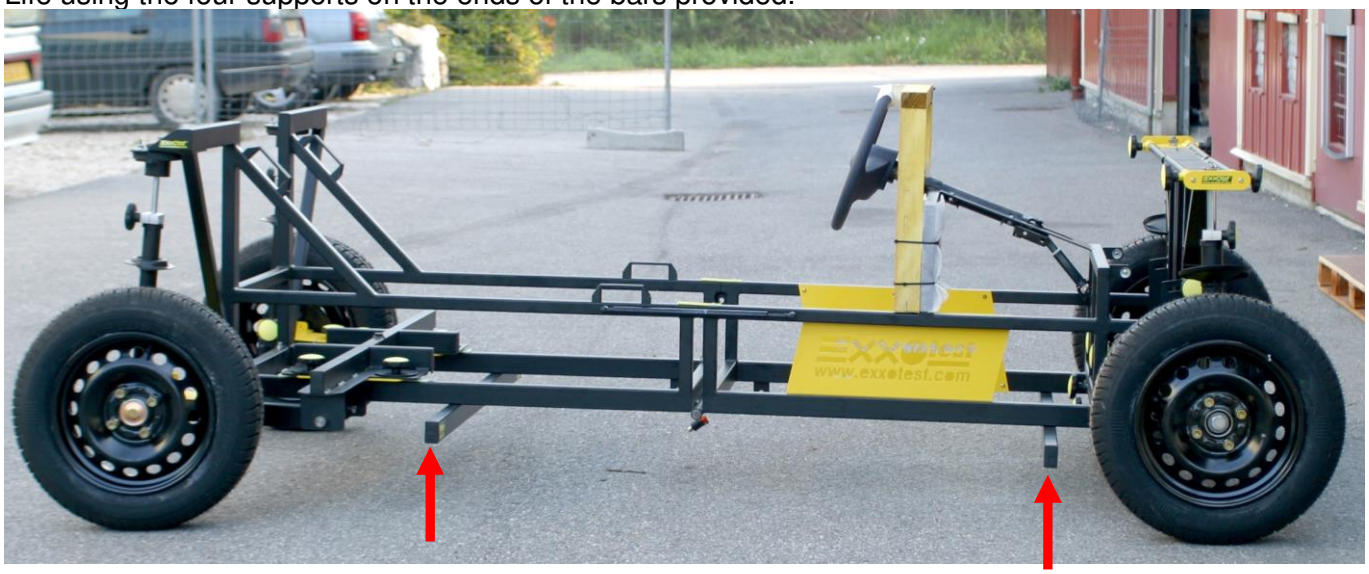
Moving the unfolded chassis: the chassis can be moved like a car – stand to the left of the chassis and hold the steering wheel. Push the model and steer with the steering wheel to go where you like on horizontal ground.

Environment

⚠ The trainer is the only person authorised to fold-up or unfold the chassis, and no trainee should be nearby.
Limit on use: This model is not a vehicle; you must not sit in or stand on it to move around.

Handling the chassis using a lift truck

Life using the four supports on the ends of the bars provided.



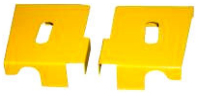
Safety device

On the chassis, a safety feature is provided by the damper gas springs which help when opening the chassis. They prevent the chassis from opening suddenly and damaging the equipment.
Checking the efficacy of the damper gas springs: when the two damper gas springs are operating effectively, the opening process finishes smoothly.
If you notice that the chassis opens more quickly and/or noisily, it is because one or both of the cylinders need replacing.
When replacing the damper gas springs, always replace both of them.

Calibrating the chassis


FR template


RR template


RH & LH front wishbone templates


Length gauge/spanner

The chassis is calibrated using the templates and length gauge/spanner provided (for use by the trainer only). Using these parts, the chassis can be quickly returned to its “original Twingo configuration” (with more precise adjustment possible using a portable wheel alignment unit).

Cleaning

Use a clean and soft cloth and a window-cleaning product.

Number of work stations and position of user

The MT-TWINGO chassis is a single work station.

Lockout/Tagout procedure

After using the chassis in the front axle assembly zone, only the trainer is authorised to lock the chassis in its folded configuration and to move it into its storage area while out of use.

Residual risk

⚠ The trainer is the only person authorised to fold-up or unfold the chassis, and no trainee should be nearby.
Limit on use. This model is not a vehicle; you must not sit in or stand on it to move around.

Transporting the chassis

One person on their own can move and handle the chassis within the workshop (on a flat surface). The four brakes must be unlocked before pushing the chassis by “driving” it from the side as you would a car.

2.2. PRESENTATION OF THE LEARNING CHASSIS

EXXOTEST's MT-TWINGO chassis provides the ideal learning aid for studying and understanding the adjustment options for front and rear axle assemblies. This foldable chassis faithfully represents all aspects of a Renault TWINGO chassis. All the faults which affect this car in real life can be simulated on this chassis. It can be used on conventional axle assembly inspection stations and the manufacturer's data for the Renault TWINGO is applicable.

This learning aid helps the trainee to learn how to adjust the following:

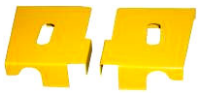
- On the front axle assembly: SAI, caster angle, camber, parallelism (toe-in/out), included angle, steering rack height
- On the rear axle assembly: thrust angle, parallelism (toe-in/out), camber angle, rear scrub radius

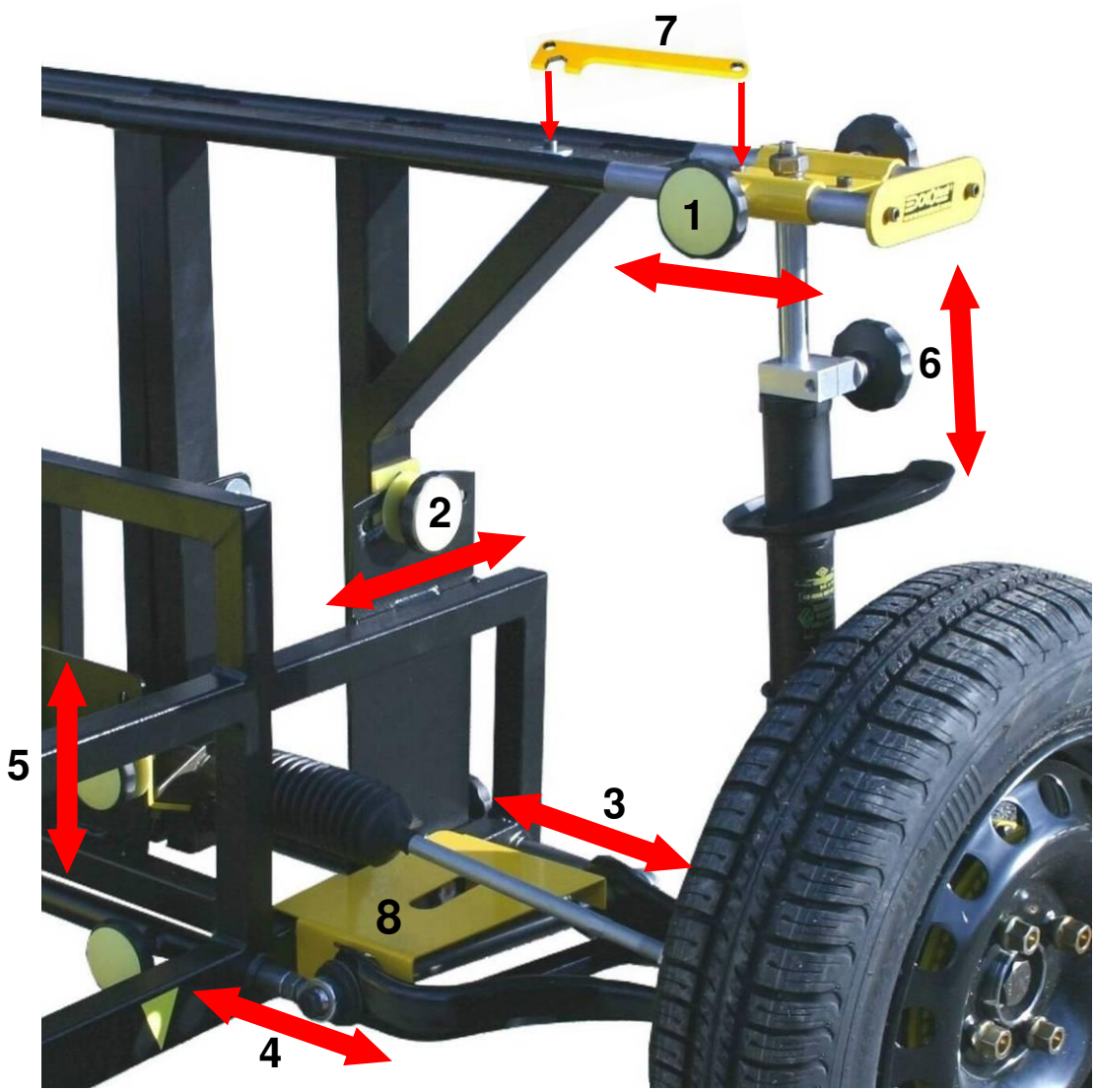
Included with the MT-TWINGO chassis at delivery are all the instructions for use and the accessories needed to return the chassis quickly to its original configuration.

The chassis can be folded up to reduce the storage space it requires in the workshop.

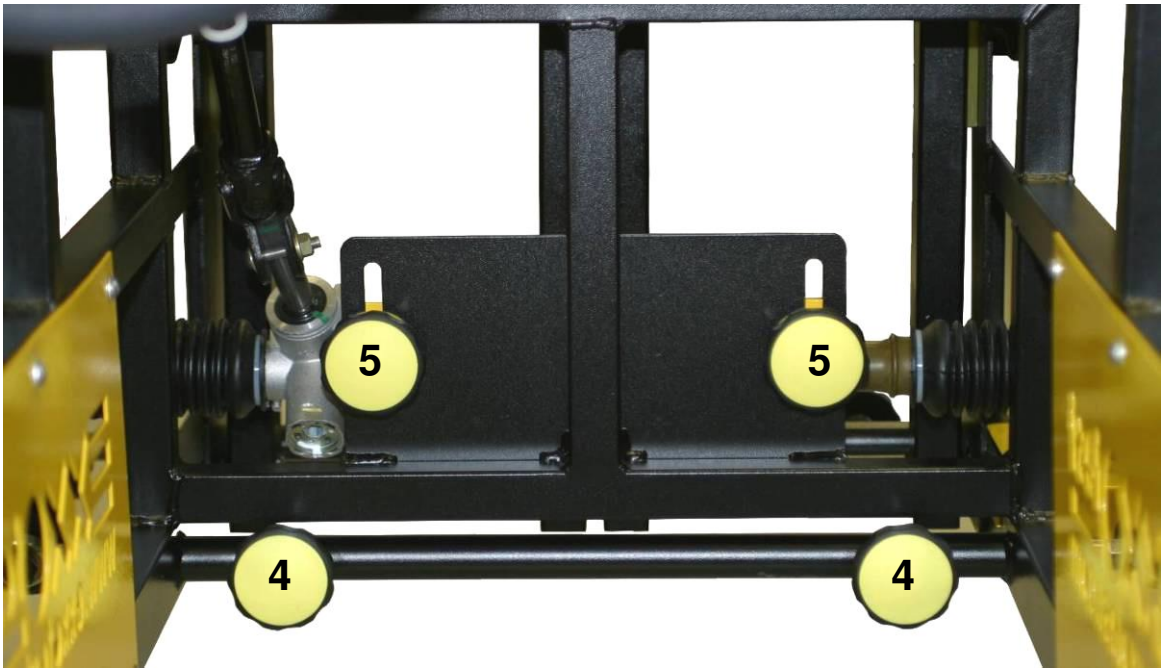
2.2.1. Description of front axle assembly adjustments

Legend for the photo on the next page:

- **1: Adjusting the front steering axis inclination (SAI)**
  Set the chassis to its original configuration using the length gauge/spanner provided:
- **2: Adjusting the front caster angle**
  Set the chassis to its original configuration using the length gauge/spanner provided:
- **3 and 4: Adjusting the position of the front lower wishbone**
  Set the chassis to its original configuration with the templates provided: 
- **5: Adjusting the steering rack height**
- **6: Adjusting the front ride (body) height**
  Set the chassis to its original config. using the front template  (same for rear )
- **7: The length gauge/spanner** is used to set up the following (for use by the trainer only):
  front SAI, FR and RR caster angle, front parallelism (toe-in/out) and rear thrust angle.
- **8: Templates** (one for the front right and one for the rear left), 
  used to return the wishbones to their standard position:



1: Using the length gauge/spanner to return the front SAI to its original configuration.
2: Using the length gauge/spanner to return the front caster angle to its original configuration.



5: Thumbwheels to adjust the height of the steering rack
original configuration: rack at its low-stop position

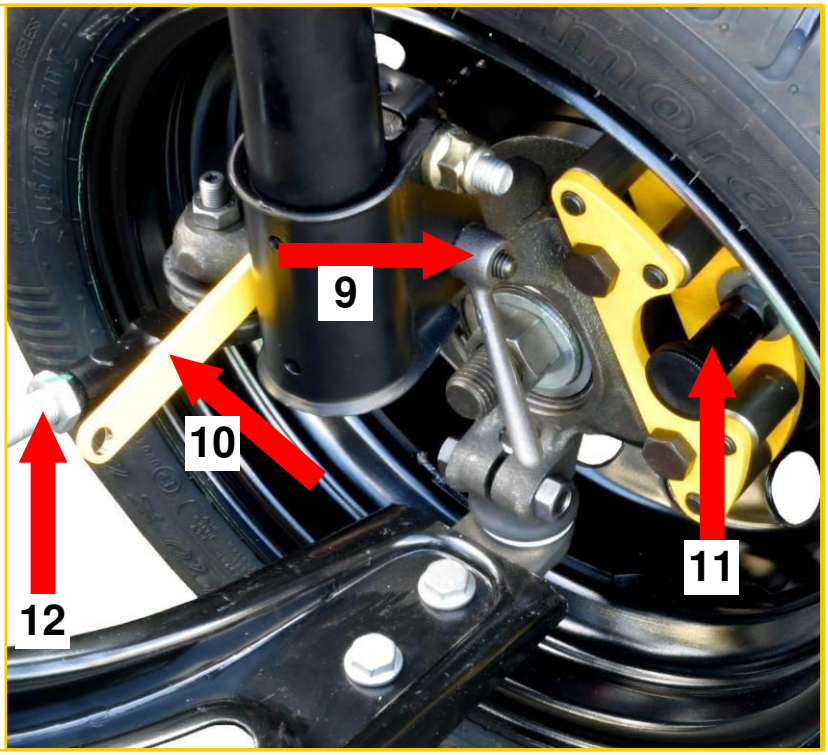
4: Thumbwheels to adjust the position of the rear mounting points for the lower wishbone.
Use the two templates provided (right and left) to return to original configuration:

9: Adjust the front camber angle using the lever

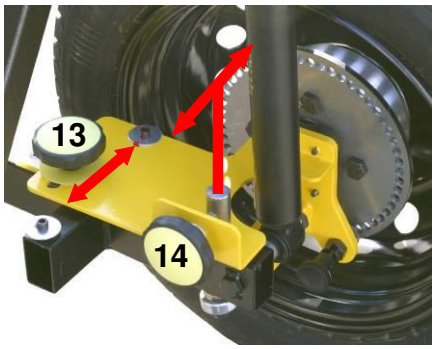
10: The length gauge/spanner can be used to hold the locknut

11: 1/4-turn locking device (all 4 wheels are equipped)

12: Adjust the front parallelism

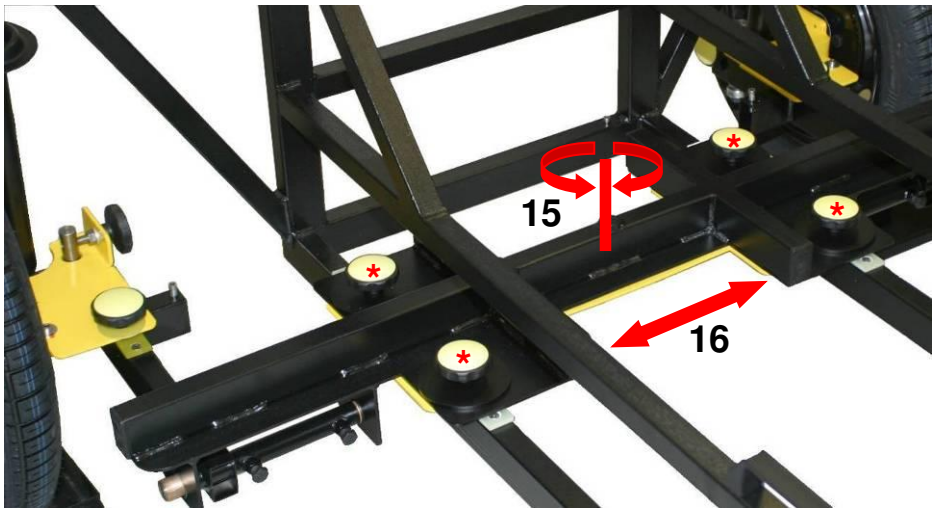


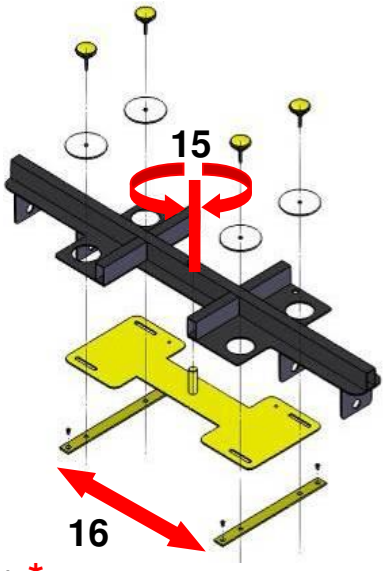
2.2.2. Description of the adjustments of the rear axle assembly



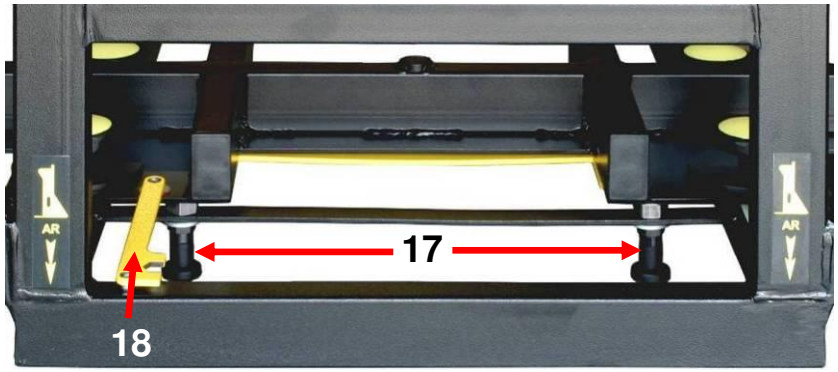
13: Adjustment of rear parallelism (each wheel adjustable independently of the other). Return to original configuration using the length gauge/spanner provided.

14: Adjustment of rear caster angle (each wheel adjustable independently of the other). The locknut can be held with the length gauge/spanner provided.





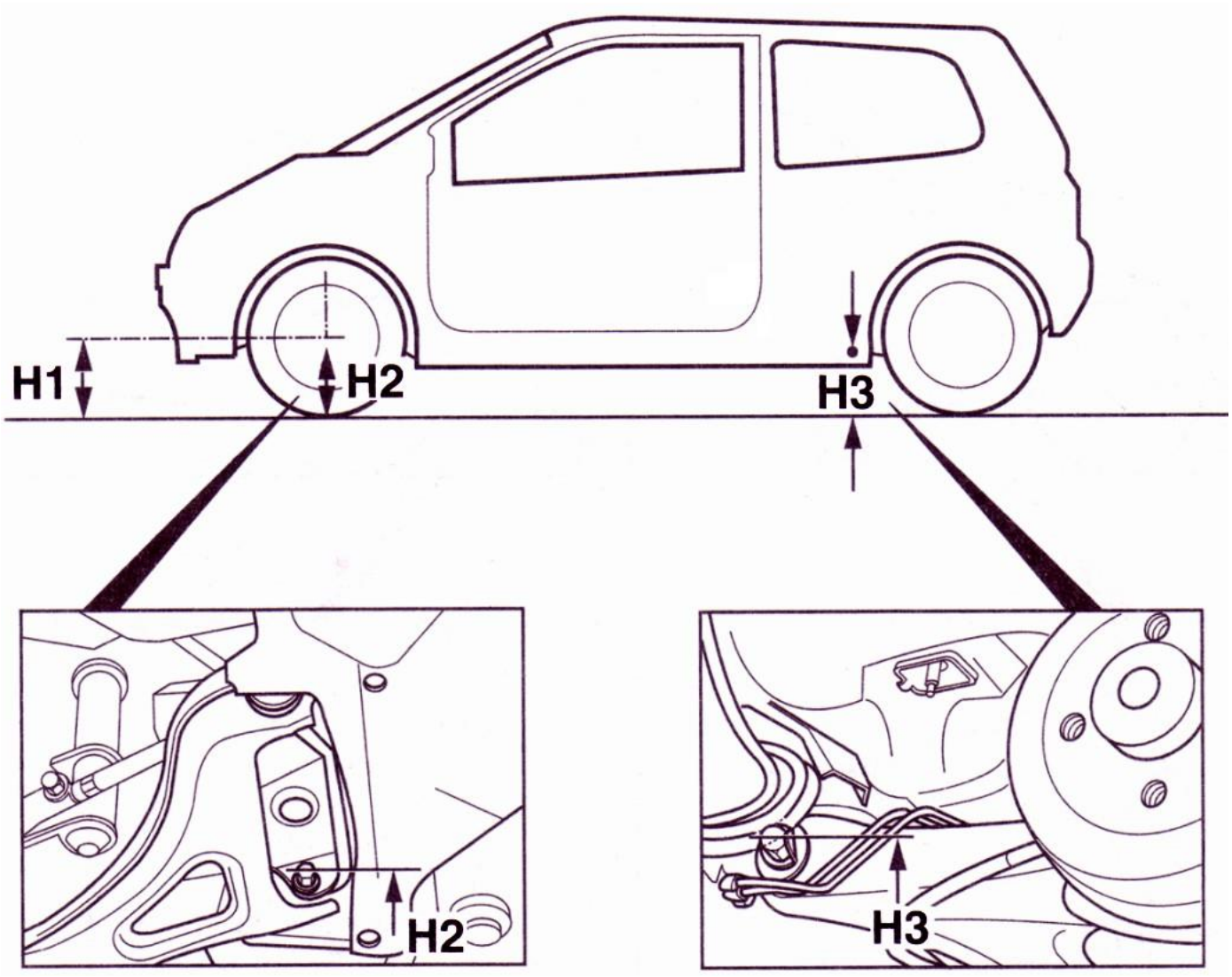
15: Adjustment of the thrust angle using the 4 thumbwheels*.
16: Adjustment of the central axis of the rear axle assembly using the 4 thumbwheels and the two guide pins located under the yellow plate.
17: Guide pins fitted under the yellow plate (¼ turn).
18: Length gauge/spanner for returning **thrust angle** to its original config.



2.3. CHARACTERISTICS OF THE LEARNING CHASSIS

Many of this model's components are identical to those fitted to the RENAULT TWINGO. The characteristics of the EXXOTEST chassis are the same as those of TWINGO (refer to the tables below).

	DIMENSION	VALUE
TWINGO	Wheelbase	2347 mm
	Front track width	1416 mm
	Rear track width	1374 mm



	VARIABLE	VALUES	TOLERANCE	BODY POSITION	ADJUSTMENT
FRONT AXLE ASSEMBLY	**Parallelism**	Toe-out: - 1 mm - 0°10’	±1 mm ±10’	Vehicle empty Tank full	1 turn of the tie rod = 3 mm (30’)
	Caster angle	2° **1°30’** 1° 0°30’ 0°	± 30’	H3-H2=12 mm **H3-H2=29 mm** H3-H2=47 mm H3-H2=64 mm H3-H2=82 mm	Vehicle: not adjustable Model: adjustable
	Camber angle	+ 0°47’ **- 0°26’** - 0°30’ + 0°05’	± 30’	H1-H2= 0 mm **H1-H2=74 mm** H1-H2=89 mm H1-H2=150 mm	Vehicle: not adjustable Model: adjustable
	SAI	+ 8°15’ **+ 10°32’** + 10°50’ + 11°27	± 30’	H1-H2= 0 mm **H1-H2=74 mm** H1-H2=89 mm H1-H2=150 mm	Vehicle: not adjustable Model: adjustable
REAR AXLE ASSEMBLY	**Parallelism**	Toe-in: 2 mm 0°20’	± 3 mm ± 30’	Vehicle empty Tank full	Vehicle: not adjustable Model: adjustable
	Camber angle	- 0°30’	± 20’	Vehicle empty Tank full	Vehicle: not adjustable Model: adjustable

The values written in bold are the values obtained after using the model’s templates/gauges.

3. EXERCISE FILE

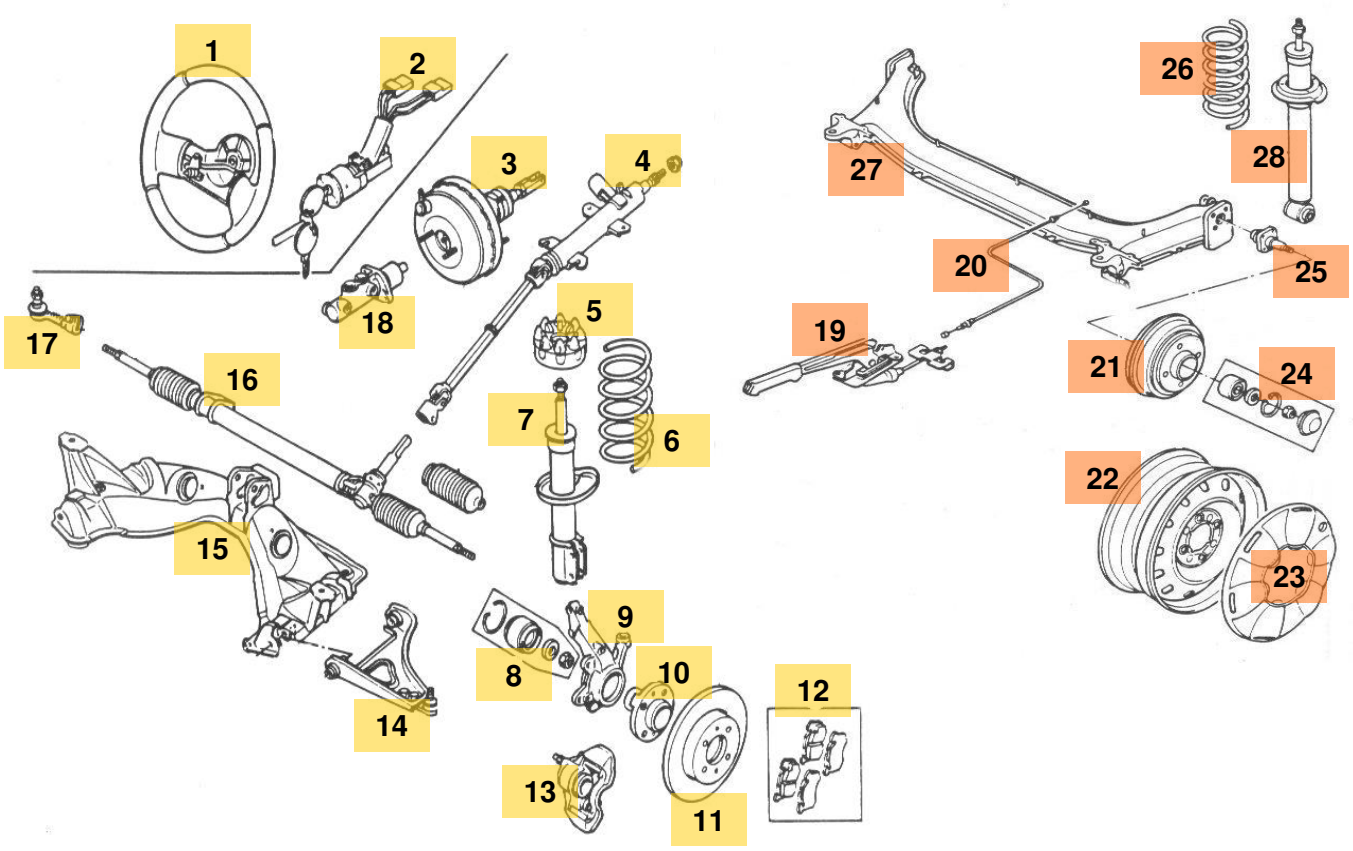
3.1. Practical exercise (PE) No.1

(PE performed by a trainee lecturer from ST DENIS IUFM (technical college) in 2006)

PE No.1 TECHNOLOGY	Surname:	First name:	Class:.....
Page No.31/47	**RUNNING GEAR**		
Vocational diploma in Engineeing	 *2 h 00*		DATE : .../.../…

3.1.1. Fill in the table with the component names listed below.

- Subframe, tie rod end, front wheel bearing, hub, lower wishbone, front shock absorber, front suspension spring, front shock mount, rear axle, rear wheel bearing, front steering knuckle (or hub carrier), rear suspension spring, hubcap, road wheel, steering wheel, ignition switch, rear shock absorber, steering column, steering rack, handbrake lever, handbrake cable, brake servo (brake booster), master cylinder, brake calliper, rear stub axle, brake disk, brake pads, brake drum.



FRONT AXLE ASSEMBLY	
1	*Steering wheel*
2	*Ignition switch*
3	*Brake servo (brake booster)*
4	*Steering column*
5	*Front shock mounts*
6	*Suspension spring*
7	*Front shock absorber*
8	*Front wheel bearing*
9	*Front steering knuckle (or hub carrier)*
10	*Hub*
11	*Brake disk*
12	*Brake pads*
13	*Brake callipers*
14	*Lower wishbone*
15	*Subframe*
16	*Steering rack*
17	*Tie rod end*
18	*Brake master cylinder*
REAR AXLE ASSEMBLY	
19	*Handbrake lever*
20	*Handbrake cable*
21	*Brake drum*
22	*Road wheel*
23	*Hubcap*
24	*Rear wheel bearing*
25	*Rear stub axle*
26	*Rear suspension spring*
27	*Rear axle*
28	*Rear shock absorber*

3.1.2. What tyre-road interface conditions need to be satisfied to ensure good road holding?

……

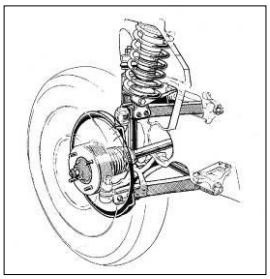
……

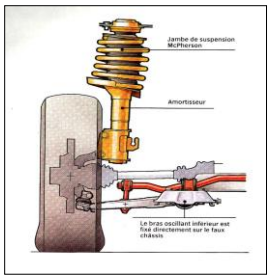
……

3.1.3. Two different design principles

Automobile manufacturers have adopted the following two types of design for front axle assemblies: draw lines to link the description to the diagram

Double wishbone system





Mac Pherson strut system

3.1.4. Running gear can be divided into 4 subassemblies
Fill in the missing text indicated by dotted lines.

- …… : consists of a spring and a shock absorber, this interface between the movement of the wheel assemblies and that of the rest of the vehicle damps out high-frequency oscillations for enhanced passenger comfort.
- …… : is used to turn the wheels to steer in the direction required by the driver, while ensuring that the tyres do not scrub on the ground.
- …… : allows the steering and suspension systems to function in a manner which is compatible with the correct rolling of the road wheels.
- …… : transmits the driving and braking forces and absorbs lateral forces of all types.

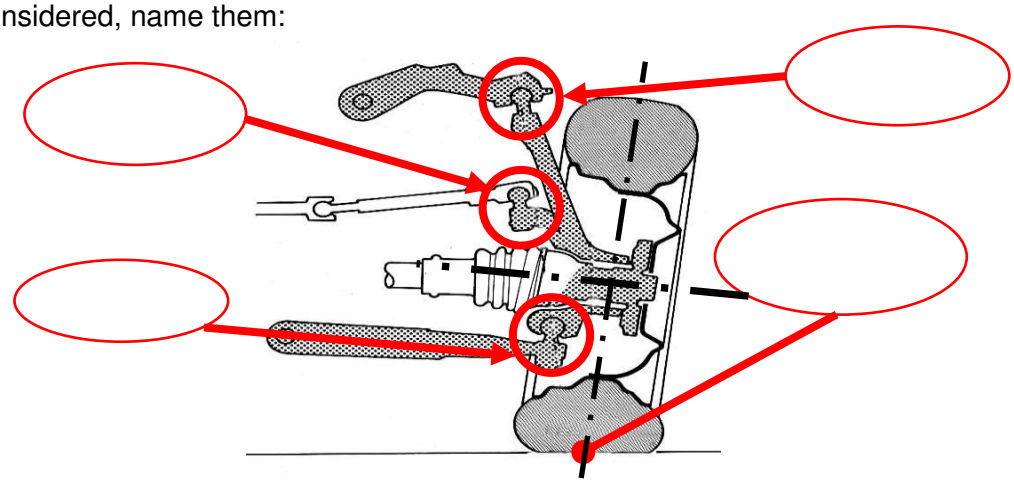
3.1.5. Scrub radius

Irrespective of which design principle is adopted by the automobile manufacturer for the running gear, the scrub radius must be very small. What three techniques are used by automobile manufacturers to reduce the scrub radius?

- ……
- ……
- ……

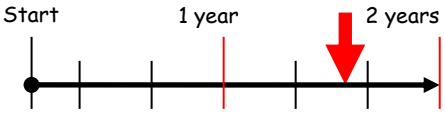
3.1.6. Main points

Irrespective of the design principle adopted for the front axle assembly, the following points should always be considered, name them:



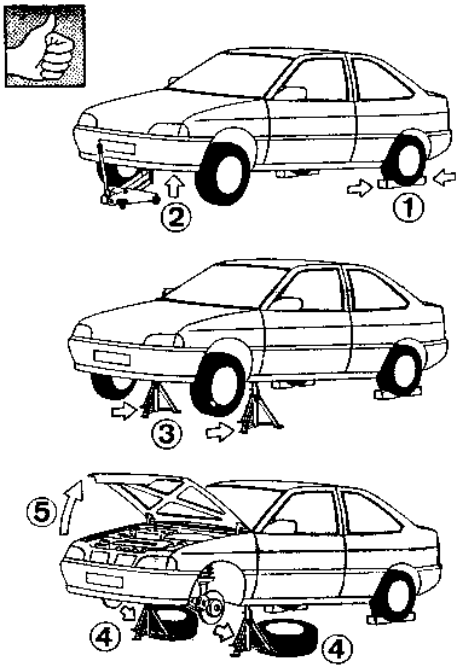
3.2. Practical exercise (PE) No.2

(PE performed by a trainee lecturer from ST DENIS IUFM (technical college) in 2006)

<table>
<tr><td>PE No. 2 MEASURING</td><td colspan="2">Surname: .....</td><td>First name: .....</td><td>Class:.....</td></tr>
<tr><td>Page No.34/47</td><td colspan="3">RUNNING GEAR</td><td> 
</td></tr>
<tr><td>Vocational diploma in Engineeing</td><td>  </td><td>4 h 00</td><td> 
</td><td>DATE: .../.../…</td></tr>
</table>

3.2.1. Preparing the MT-TWINGO learning chassis model in readiness for studying the running gear

Move the vehicle assigned to you to the running gear work station and position it correctly (i.e. correctly centred).



Prevention of accidents:

Demonstrate to your trainer that you know how to use the four-post lift.
Raise the vehicle using the four-post lift.
Lower the vehicle using the four-post lift.
Check that the safety feature is working by stopping at mid-height (four-post lift).

What is the maximum load that this vehicle lift can support?

_____

Can it safely support the mass of the vehicle which you are inspecting?

☐ YES ☐ NO

Explain your answer: _____

On the two-post lift, one support arm is longer than the other, why?

_____

_____

Trainer's signature

OK → ***YES*** ***NO***

You may continue if YES is circled.

3.2.2. Preliminary checks

Ensure that you are familiar with the instructions for the running gear alignment unit and perform the following preliminary checks.

1/ Check of the tyre pressure:

	OK	Not OK
- Pressure measured for FR RH wheel: _____ Manufacturer's value: _____	☐	☐
- Pressure measured for RR RH wheel: _____ Manufacturer's value: _____		
- Pressure measured for FR LH wheel: _____ Manufacturer's value: _____	☐	☐
- Pressure measured for RR LH wheel: _____ Manufacturer's value: _____	☐	☐
- Visual inspection of the general condition of the tyres:	☐	☐

_____
_____

2/ Check of the play and condition of the running gear's ball joints (or tie rod ends):

	OK	Not OK
- Play and tightening torque:	☐	☐
- Condition of the ball joint boots:	☐	☐

3/ Check of the ground clearance:

	OK	Not OK
- Measurements of the heights at the FR:	☐	☐
- Measurements of the heights at the RR:	☐	☐

4/ Check of the suspension:

	OK	Not OK
- Travel and play of the FR suspension:	☐	☐
- Travel and play of the RR suspension:	☐	☐

5/ Check of the steering (play and travel):

	OK	Not OK
- Comparison of the steering angles	☐	☐
6/ Check of the play in the hubs:	☐	☐

7/ Visual observation of the general condition of the underside of the vehicle:

_____
_____

Indicate any anomalies observed:

_____
_____

3.2.3. Assembly of the sensor pods and turntables

Perform the following operations:

- Assemble and connect the sensor pods
- Check by pulling on the pods that they cannot fall off.
- Install fall protection systems if provided.
- Power up the running gear alignment unit.
- Raise the vehicle or model and place the turntables under the front wheels.
- Fit height compensation plates under the rear wheels if necessary, or release the rear ball-bearing plates.

3.2.4. Runout compensation

Perform the following operations:

Based on the instructions provided for the running gear alignment unit, perform the runout compensation operation.

3.2.5. The complete measurement

Perform the following operations:

Based on the instructions provided for the running gear alignment unit, perform all the operations necessary to make the measurement.
When steering, ensure that the sensor pods do not touch the wings or bumpers.

Note for when working on a actual road vehicle (not necessary on the model): when fitting a brake pedal depressor, start the engine to benefit from brake assist.

3.2.6. Record the values on the vehicle or on the model

- Record the values measured in the table on the following page
- Look up the manufacturer's values for the vehicle and enter them in the table also
- Indicate whether or not the value can be adjusted
- Compare the various values
- Indicate the values which are correct, and those which fall outside the acceptable values

Vehicle identification details (do not complete this table if you are using the model!)				
Make	*Commercial name*	*Type*	*Kilometrage*	*Registration No.*

CHECK OF THE RUNNING GEAR						
	Manufacturer's values		Is adjustment possible?	**Measured values**		Conclusion
	Max.	Min.	Yes/No	Left	Right	Ok/Not Ok
FRONT AXLE ASSEMBLY						
Overall parallelism						
Partial parallelism						
Camber angle						
Caster angle						
SAI						
Included angle						
Scrub radius						
Steering						
REAR AXLE ASSEMBLY						
Overall parallelism						
Partial parallelism						
Camber angle						
Thrust angle						

3.2.7. Report your measurements orally to your trainer

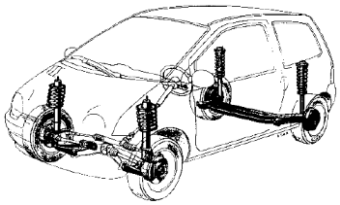
3.2.8. Adjust the parallelism (toe-in/out)

- Set the steering in its straight ahead position (refer to the resources file) and fit the steering wheel holding device.
- Adjust the parallelism: overall parallelism correct + partial parallelism correct (refer to the resources file).
- Tighten the adjustment bolts or nuts to the correct torque (refer to the published values).
- Torque value: _____.
- Centre the steering wheel, if necessary.
- Caution: Do not touch the steering wheel if it is fitted with an airbag.
- Call the trainer to check, then explain orally the adjustment procedure. for parallelism.

3.2.9. Tidying away the work station

- Stow all the elements of the running gear alignment unit
- Remove the steering wheel holding device and the brake pedal depressor
- Remove the turntables and the height compensation plates from under the wheels.

3.3. Effect of braking on running gear geometry

DOCUMENT No. Name:…… Class:……..….	**Running gear geometry**	
Type of document **LEARNING AID**	**Effect of braking on running gear geometry**	

1) Setting up the workstation

➢ **PUT IN PLACE:**

- The equipment specific to the inspection:
  - Wheel alignment unit and accessories.
- Vehicle lifting equipment:
  - Trolley jack.
  - 4 axle stands.

➢ **PREPARE:**

- The selected work zone.
- The MT-TWINGO model.

2) Calibration of the MT-TWINGO model

Based on the information provided in the user manual for the MT-TWINGO, calibrate this model using the accessories provided (calibrate = set to the manufacturer's recommended values).

3) Setting up the wheel alignment unit

⚠ **Precautions:** Check that all the adjustment thumbwheels are screwed in fully, and that the wheel bolts are secure.

- Support the model on the 4 axle stands.
- Lock the 4 wheels to stop them turning (using the ¼-turn locking pins).
- Fit the sensor pods to the wheels.
- Connect the wires to the 4 sensor pods (if using a wire-connected wheel alignment unit).

Minimise all potential obstacles

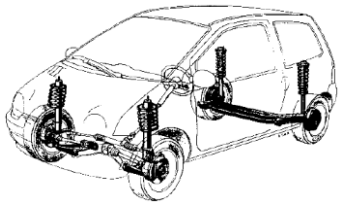
- Lay the cables so that there are no loops which might create a tripping risk.
- Move the trolley jack away from the work area.

☑ *Call over your trainer to check that everything is set up correctly.*

4) Run the runout compensation test

Follow the procedure described in the wheel alignment unit's manual.

⚠ Ensure that the wheels are locked to immobilise them when obtaining each measurement.

DOCUMENT No. Name:…… Class:……..…	**Running gear geometry**	
Type of document **LEARNING AID**	**Effect of braking on running gear geometry**	

5) Take the measurements, with the model set up to the manufacturer's values

Lower the model to the ground, in compliance with the instructions relating to safety & ergonomics.

⚠ **Precautions:** Remember to place the turntables under each wheel. Lock all the wheels before lowering the model to the ground.

Take a complete set of measurements of the geometry of the running gear in accordance with the method described in the wheel alignment unit's user manual.

Correct the parallelism (toe) if necessary.

Print out the table of measurements sheet.

☑ *Call over your trainer to validate this step.*

6) Take the measurements, with the model in a "braking" configuration

To simulate a braking configuration:
- Lower the front ground clearance by 30 mm.
- Raise the rear ground clearance by 30 mm.

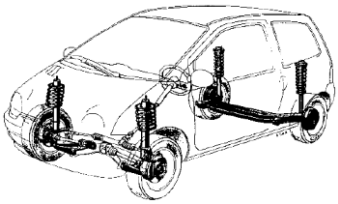
Take a complete set of measurements of the geometry of the running gear in accordance with the method described in the wheel alignment unit's user manual.

Print out the table of measurements sheet.

☑ *Call over your trainer to validate this step.*

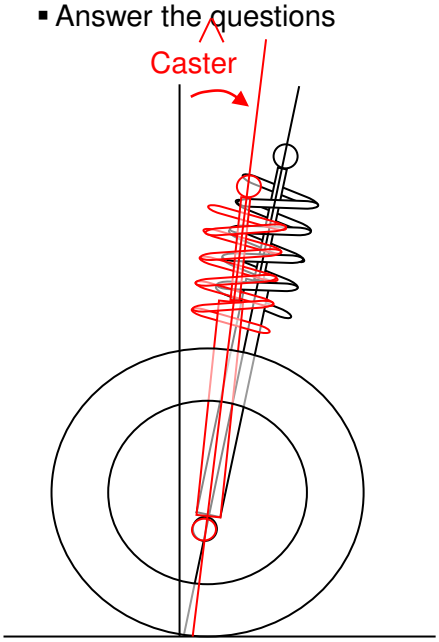
7) Complete the table below

FR LH running gear	Cruising configuration	Braking configuration	Difference
Caster angle	+ 01 ° 30 '	+ 0 ° 20 '	- 01 ° 10 '
SAI	+ 11 ° 60 '	+ 11 ° 60 '	0 ° 00 '
Camber angle	- 0 ° 30 '	- 0 ° 30 '	0 ° 00 '
Partial parallelism	0 ° 00 '	+ 0 ° 90 '	+ 0 ° 90 '

DOCUMENT No. Name:…… Class:……..…	**Running gear geometry**	
Type of document **LEARNING AID**	**Effect of braking on running gear geometry**	

8) Changes to the geometry when braking

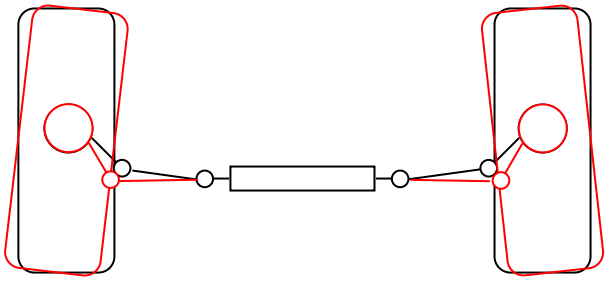
- The diagram below shows the components of a half-axle in cruising configuration. Draw, on top of this diagram, the same components when in a braking configuration. Indicate the angles which have changed.
- Answer the questions



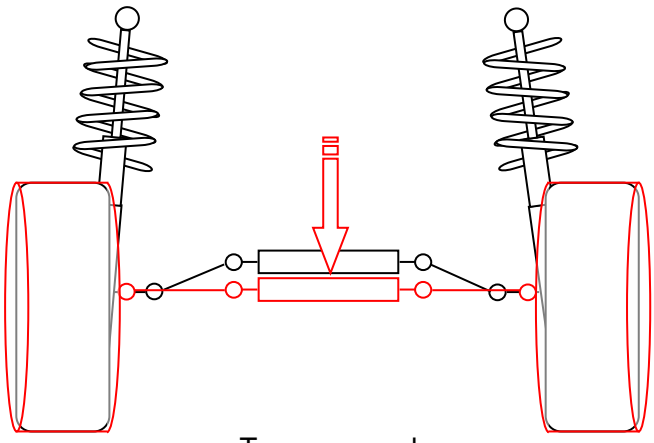
Q1. How does the scrub radius change (longitudinal scrub radius) when braking?
…....The scrub radius tends to reduce ……..…….....
……..…….....

Q2. In terms of road handling, what is the effect of the change in this angle?
……The narrowing of the caster angle reduces the scrub radius and as a result the steering become slightly less stable.…….....

…Longitudinal…..plane

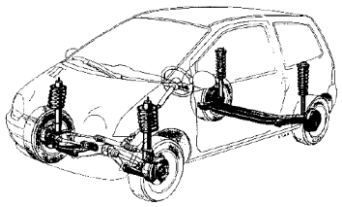


Horizontal plane



Transverse plane

Q3. What effect does braking have on the parallelism (toe)? What are the negatives?
……..Braking creates toe-in. The tyres scrub more which tends to result in less adherence and longer braking distances …….....

DOCUMENT No. Name:…… Class:……..…	**Running gear geometry**	
Type of document **LEARNING AID**	**Effect of braking on running gear geometry**	

9) Effect of the height of the steering rack

- Using the model's axle stands, calibrate the ground clearance.
  (in cruising configuration)
- Set the height of the steering rack to its upper stop position.
  (refer to the model's user manual for a description of how to adjust the steering rack height)
- Set the parallelism (toe) to the manufacturer's values.
- Repeat the measurement tasks described in sections **5)** and **6)** of this learning aid.
- Print out the summary for each measurement.
- Answer the following questions.

Q4. How does the position of the tie rod ends change when the steering rack height is moved from its lower stop position to its upper stop position?

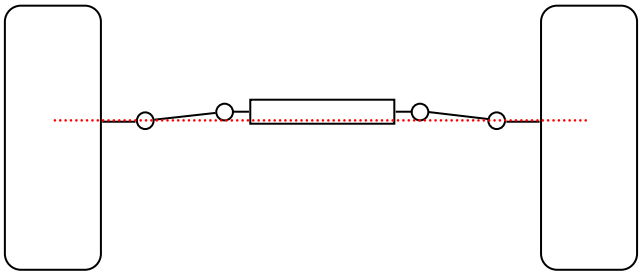
The slant of the tie rod ends increases when the height of the steering rack is moved to its high stop position.

Q5. With the steering rack in its new position, is the variation in the parallelism increased or decreased by a transition from a cruising configuration to a braking configuration?

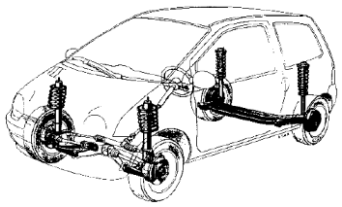
The change in the height of the steering rack increases the variation in the parallelism when transitioning from cruising to braking.

Q6. What steering rack height would reduce this variation the most? (express your answer by relating the height of the steering rack to the degree of slant of the tie rod ends)

To decrease this variation in parallelism, the tie rod ends should oscillate around the horizontal level as the suspension absorbs the up and down movement of the wheels. To achieve this optimally, the steering rack must be positioned slightly above the straight line between the ball joints when the vehicle is in cruising configuration.



Transverse plane

DOCUMENT No. Name:…… Class:……..…	**Running gear geometry**	
Type of document **LEARNING AID**	**Effect of braking on running gear geometry**	

10) Clearing the work station

➢ **CLEAR AWAY:**

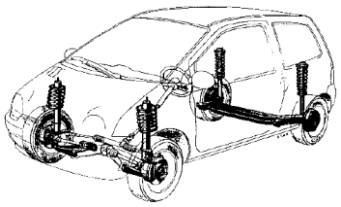
- The equipment specific to the inspection:
  - Wheel alignment unit and accessories.
- Handling equipment:
  - Trolley jack.
  - 4 axle stands.

➢ **RETURN TO STORAGE:**

- The work area.
- The MT Twingo model.

Refer to the model's user manual for details about folding-up the model

☑ *Call your trainer to review your work and to fill in the evaluation sheet.*

DOCUMENT No. Name:…… Class:……..…	**Running gear geometry**	
Type of document **EVALUATION SHEET**	**Effect of braking on running gear geometry**	
Type of evaluation **FORMATIVE** ☐ **SUMMATIVE** ☐	**OBJECTIVE(S)** To explain the effect of braking on the geometry of a vehicle's running gear.	
Date:……..	**CONDITIONS UNDER WHICH THE TEST IS PERFORMED** In the workshop, on the MT Twingo learning model. Based on knowledge acquired regarding the geometry of running gear.	

Skills evaluated	Evaluation criteria	Satisfied	Partially satisfied	Not satisfied	Score
☐ C 2.1.1	Setting up the work station				
☐ C 1.3.1	Searching for and finding technical data in the resource documents				
☐ C 4.1.2	Assessing professional risks				
☐ C 2.2.3	Taking measurements using the wheel alignment unit				
☐ C 2.2.4	Explaining, based on the measurements made, how the running gear components move in space when in braking configuration				
☐ C 2.2.6	Defining, based on the measurements made, the effect of braking on running gear geometry				

Score: ……. / 10

Evaluation of the written work in the guidance document:

- FR LH running gear geometry table …….. ……/1
- Figure 1 : …… ……/1
- Figure 2 : …… ……/1
- Figure 3 : …… ……/1
- Question 1 : …… ……/1
- Question 2 : …… ……/1
- Question 3 : …… ……/1
- Question 4 : …… ……/1
- Question 5 : …… ……/1
- Question 6 : …… ……/1

Score: ……. / 10

…… / 20

CE DECLARATION OF CONFORMITY

With this declaration of conformity, the company:

S.A.S. ANNECY ELECTRONIQUE
Parc Altaïs – 1, rue Callisto
F74650 CHAVANOD

Declares that the following product:

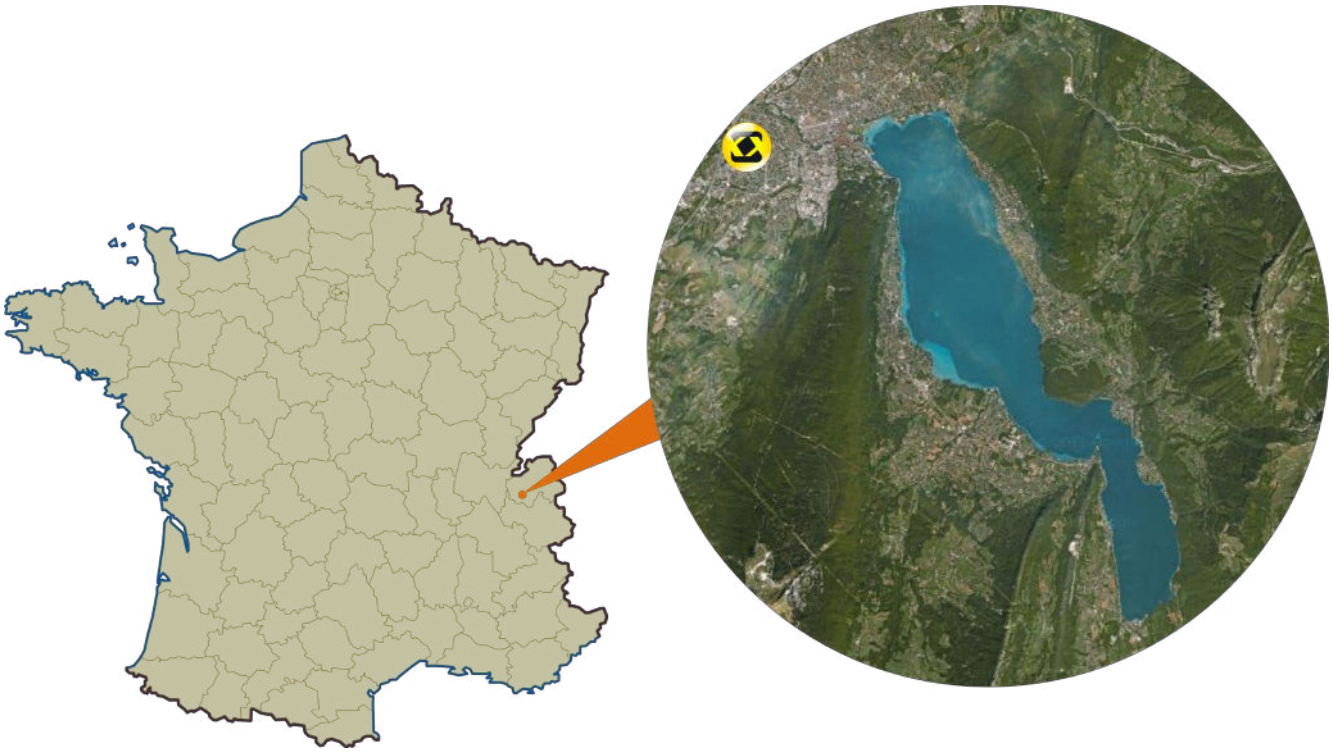
Make	Model	Description
EXXOTEST	**MT-TWINGO**	**LEARNING MODEL:** Study of running gear – Adjustable chassis

I - has been manufactured in accordance with European directives and meets the requirements of the following standard:

- EN 61326-1:1997 + A1:1998 + A2:2001

Signed in Saint-Jorioz on 24 July 2007

Stéphane Sorlin, Chairman



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