Mécanique

Dynamique

Mechanics

Dynamics

Ref :
332 027

Français – p 1

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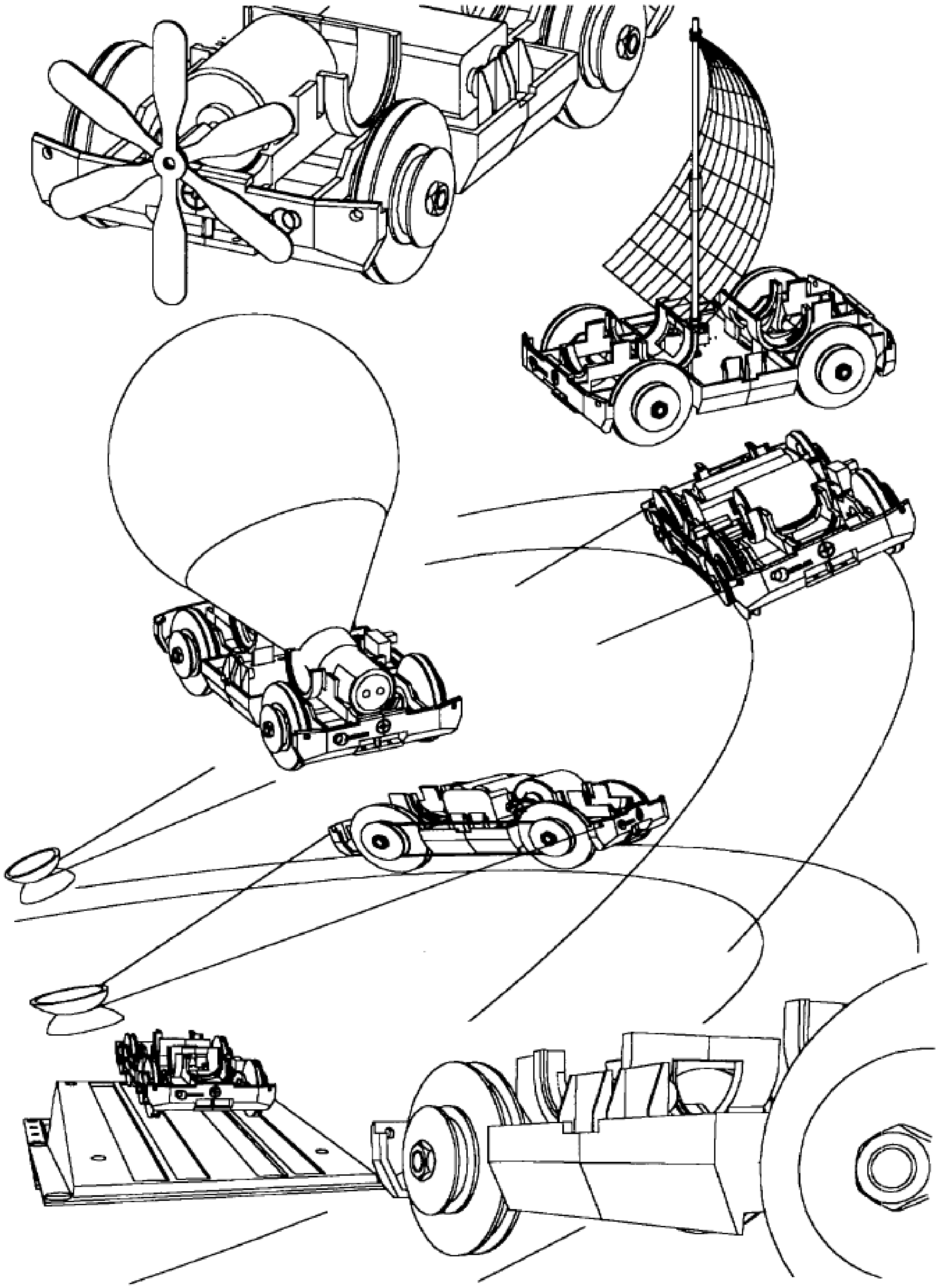
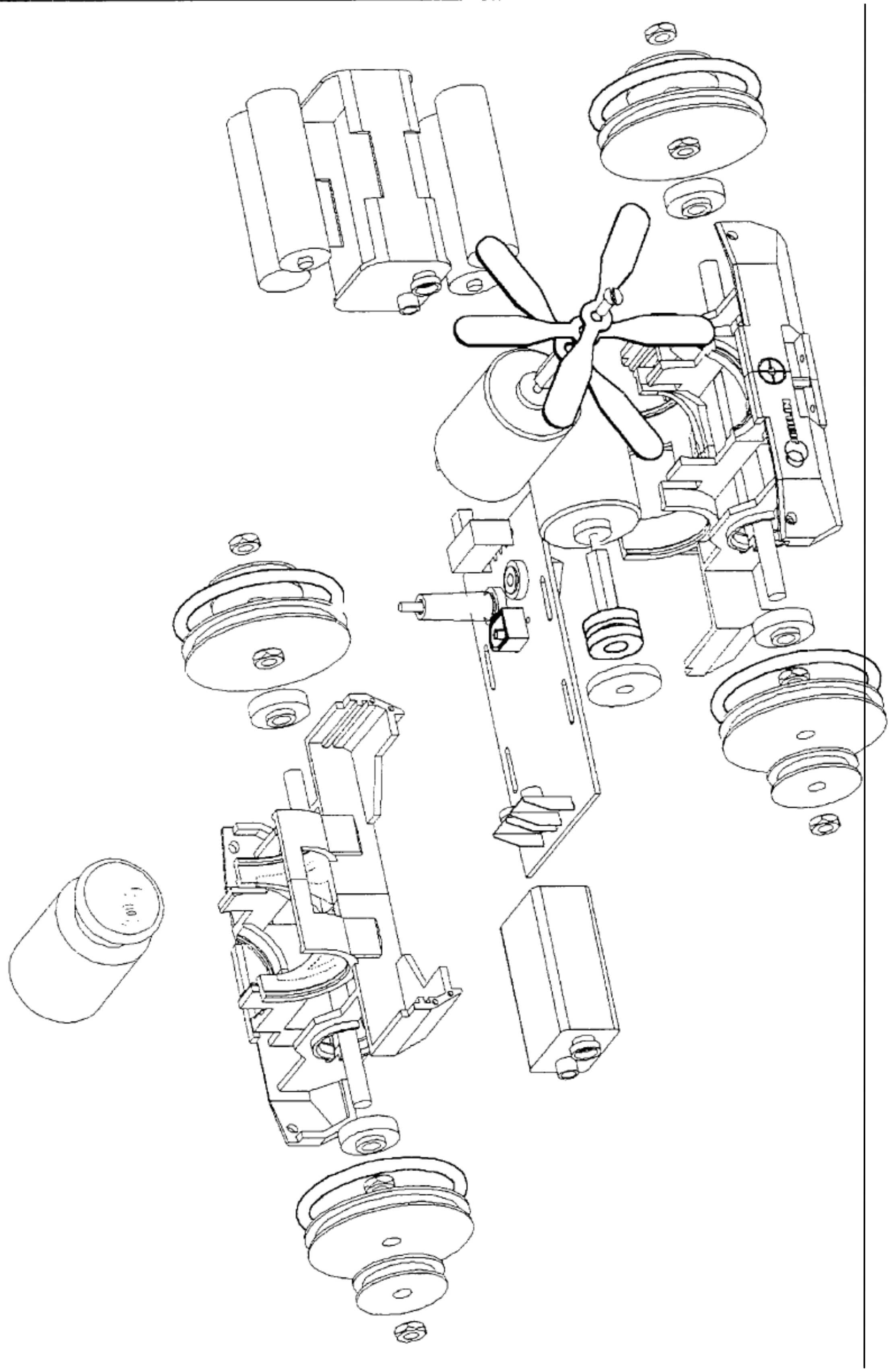
Version : 9003

Véhicule toutes propulsions

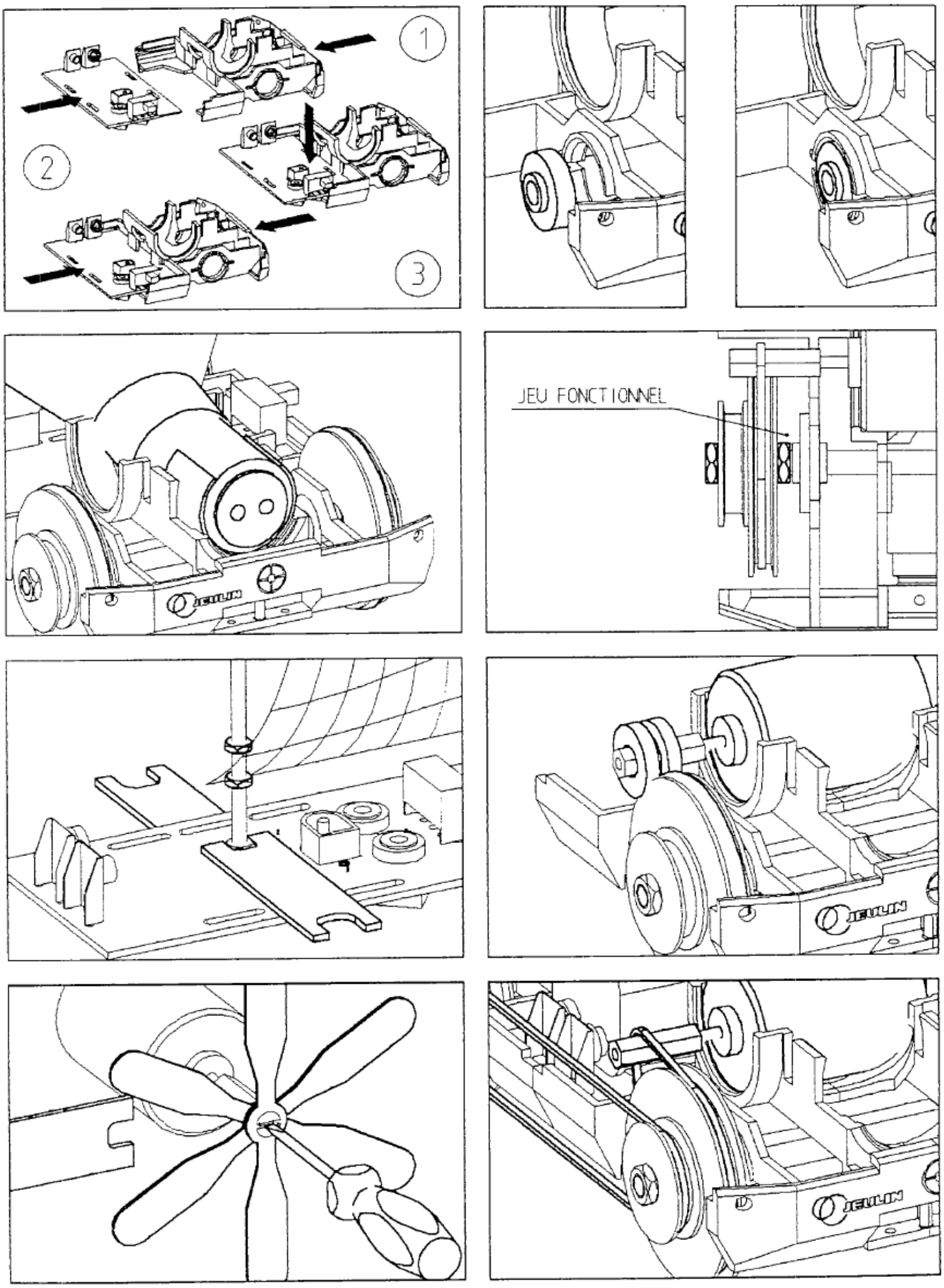
Multi-propulsion vehicle

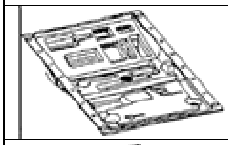
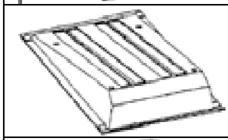
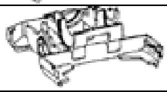
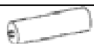
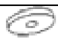
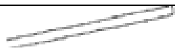
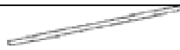
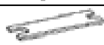
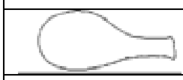
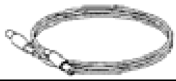


ECLATE



MONTAGE



PART	No.	DESCRIPTION	MATERIAL WEIGHT	PART	NO.	DESCRIPTION	MATERIAL WEIGHT
	1	STORAGE RACK	PS 209 g		4	PULLEY dia. 40 ext dia. 45	PA 9.3 g
	1	ADJUSTABLE RAMP	PS 203 g		4	PULLEY dia. 20 ext dia. 25	PA 2.7 g
	1	BODYWORK	PVC 19.5 g		4	O-RING dia. 3.6	NITRILE 1.6 g
	2	½ CHASSIS	ABS 24 g		4	BEARING dia.5-dia.16	STEEL 4 g
	1	PRINTED CIRCUIT	EPOXY 24.5 g		10	RUBBER BAND 40 mm	RUBBER 0.2 g
	1	MOTOR	77 g		10	RUBBER BAND 80 mm	RUBBER 0.4 g
	1	4X1.5V BATTERY COUPLING DEVICE	8 g		2	FRICTION ROLLER	RUBBER 1 g
	-	1.5V BATTERY TYPE R6(014)	18.5 g		2	8-TERMINAL DETECTOR	3.5 g
	-	9V BATTERY TYPE 6F22	45 g		2	THREADED ROD M5 * LG. 100	STEEL 12 g
	5	PROPELLER	PP 0.5 g		2	THREADED ROD M3 * LG. 100	STEEL 4 g
	2	SQUARE HEAD SCREW M3 * LG 10	STEEL 0.5 g		12	NUT M5	STEEL 0.7 g
	1	BLOWER TUBE	PMMA 11 g		6	NUT M3	STEEL 0.3 g
	1	CORK WITH 2 HOLES	RUBBER 5.7 g		1	GUIDE PIN M3 * LG. 18	BRASS 3 g
	1	CORK WITH 1 HOLE	RUBBER 6.1 g		4	OPEN-END WRENCH	STEEL
	1	CORK	RUBBER 6.5 g		1	SCREWDRIVER	
	3	BALLOON	RUBBER 3 g		1	SUCTION CUP	PVC
					2	BRAIDED WIRE	PA
					1	POWER CORD	
					1	ROUND BOX dia. 45*ht 15	PS

PS: Polystyrene
ABS: Acrylonitrile-butadiene-styrene plastic
PP: Polypropylene
PMMA: Polymethyl methacrylate
PE: Polyethylene
PA: Polyamide

1 Introduction

This kit is designed for students for various experiments as well as teachers for lecture demonstrations.
It helps use living and concrete situations to understand the concepts of movement, velocity, force, interaction, pressure and propulsion, which are all part of the fourth year of secondary school programme. It is also a reinvestment field for electricity.
In addition to its resources, it also helps in other subjects: plastic arts, technology, mathematics and gives the student a scope for initiative and creativity where he can use his imagination. It requires a whole lot of research work and documentation which will be used for talks using audiovisual means.

2 General objectives

The experimental sheets provided, help the student become independent. In particular, it is important to show that drawings and text are two complementary modes of expression. **Learning to read them is the first step to success**. It is by going from one mode of information to the other that the overall comprehension will develop.
Stress must therefore be laid on this objective where the issue is beyond the mere framework of physics.
In return, detailed written expression and precise drawings will be required in the reports.

3 Using the equipment

There are many possibilities depending on the processes used. Either all the equipment is delivered in the initial box and the student uses the equipment necessary for a particular experiment.
Or, the parts that are not used are removed and the box contains only the parts necessary for the experiment.
In the case where the students will work independently from a central distribution station, the different parts will be removed from their original boxes and grouped together in a set of boxes. Only the ones required for the defined objective will be used.

4 Experiments

A non-exhaustive list of experiments is provided. Various approaches are indicated. It is for the teacher to select the most pertinent experiments according to his objectives and the level of the classes. One of the aims is to maintain the curiosity of the students at every stage.

Note
The housings of the ball bearings are slightly "tight". Initially this may create some inconvenience during set-up. It is also advised to fit the bearings on receipt of the equipment and leave them permanently to facilitate subsequent set-ups, which will be performed by the students. The "running in" will occur gradually

5 Assembly disassembly (wheel – axle)

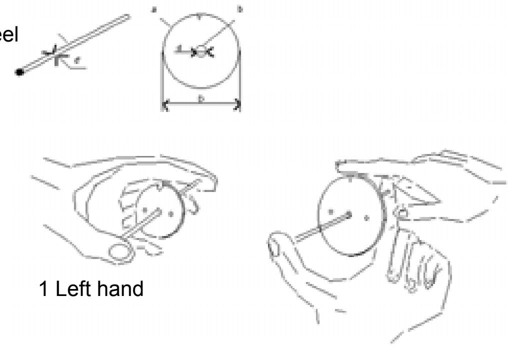
Concept of friction

Answer each question with a short sentence

Objectives:

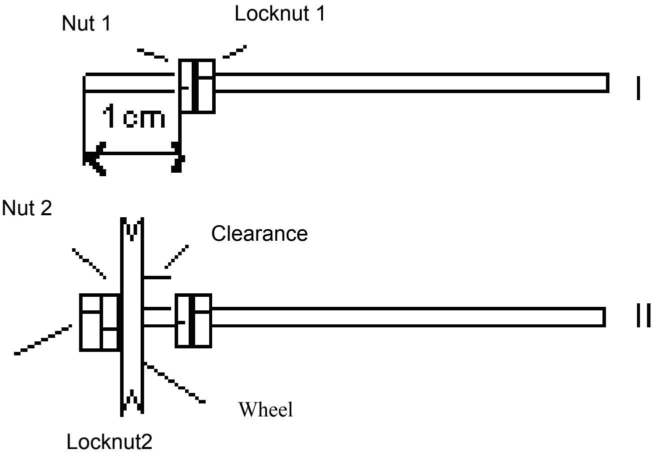
To locate and identify the basic components of the kit.
To read the drawing; assemble the free wheels linked by the axle.
Concept of friction,

I1 Free wheel

 1 Left hand 2. Rotate with the index finger of the right hand	Measure the outer diameter (D) of the wheel in millimetres Measure the diameter (d) in millimetres ; slide the threaded rod into part (b) of the wheel. What can be said of its diameter (d')? Would a strand of hair pass through between (d) and (d')? Try. Give the name of parts (a) and (b) of the wheel. Provide, according to its function, one or two synonyms for the threaded rod.

1.4 Take the threaded rod between the thumb and index finger of your left hand (see drawing 1),
hold it properly horizontal with the free wheel at its centre. Rotate as indicated (see drawing 2).
Measure the maximum duration of rotation in seconds.

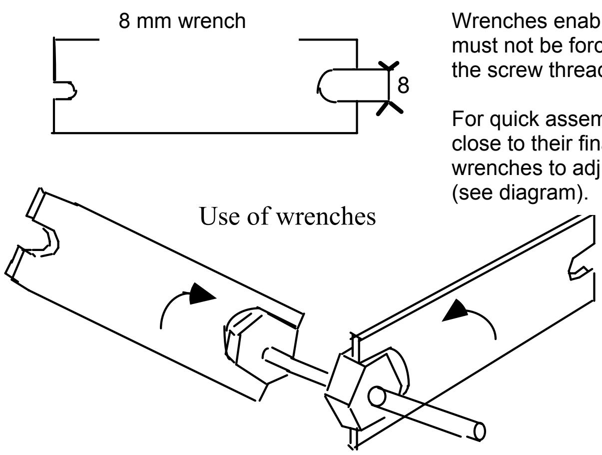
1.5 Positioning the free wheel at one end of the threaded rod using four nuts (manual assembly).



I) Thread two nuts at the end of the rod. When these re 1 cm from the end, tighten them one against the other. This operation ensures that the nuts are locked on the rod. This assembly is know as a nut, locknut system.

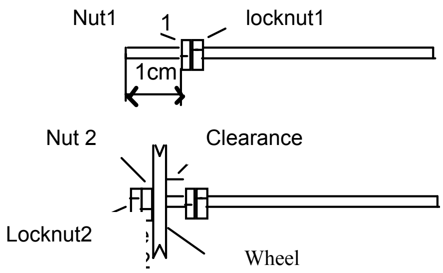
II) Insert the wheel and the locking system (nut2, locknut2).
Make a clearance (space between the nut and the wheel) small. On the drawing, estimate the clearance between nut 1 and the wheel : J1. How much is the clearance between nut2 and the wheel : J2 ?
Rotate the wheel with your index finger and measure its duration of rotation.

1.6 Nut, locknut system with tightening by an 8mm wrench



Wrenches enable a more efficient tightening, but they must not be forced, as there is a risk of damaging the screw thread.

For quick assembly, first use the fingers to bring the nuts close to their final position and then wrenches to adjust and tighten moderately (see diagram).

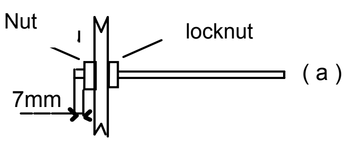


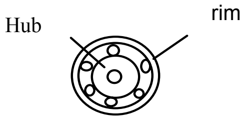
I Lock the nut (1) and the locknut (1) with the 8 mm wrench at 1 cm from the end of the threaded rod.

II Use the fingers, then the wrenches for the nut (2) and the locknut (2). In order to make the assembly (II) more efficient, the clearance must be very small, of the order of the diameter of a strand of hair. Launch manually and time the duration of rotation.

I2 Linked wheel

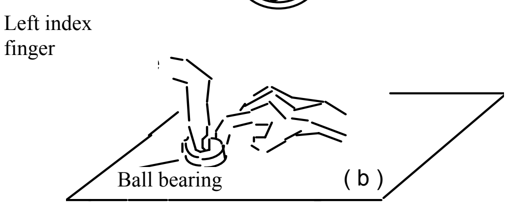
2.1 The wheel is gripped between the nut and the locknut that are tightened with the wrenches.
Position the assembly as shown in the diagram (a).
The wheel is said to be linked to the axle. How much is clearance ?



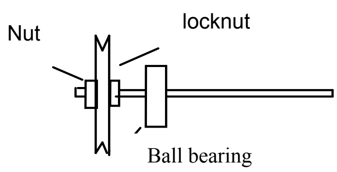


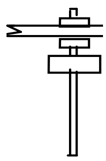
2.2 The ball bearing is a special wheel where the rim and the hub are free to rotate one with respect to the other thanks to steel balls. Count the balls and estimate their diameter.
Do the balls rotate or slide when the rim is rotated by locking the hub?

Initiate rotation, the index finger of the left hand blocks the hub and the index finger of the right hand rotates the rim, diagram (b).
Measure the duration of rotation.

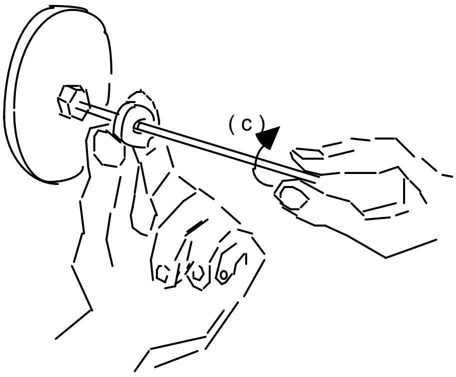


2.3 Insert the ball bearing on the threaded rod very close to the locknut. Hold it between the thumb and the index finger of the left hand (see diagram c) and rotate the threaded rod with the fingers of the other hand.
The rod will first be placed horizontally then vertically.





ENGLISH



2.4 Measure the maximum duration of rotation for each of the positions (horizontal and vertical).

2.5. Are the durations equal? Otherwise, supposing that you have given the same impulse, how do you justify the difference?

6 Assembly disassembly (Set of wheels)

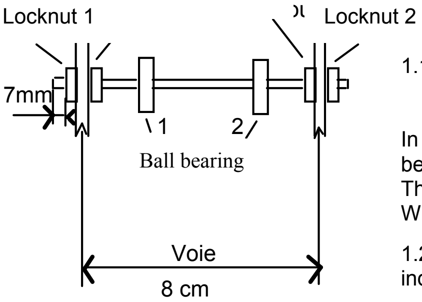
Concept of average velocity

Answer each question with a short sentence

Objectives:

To assemble a set of wheels and determine its proper operating condition
Concept of average velocity.

I1 Set of wheels



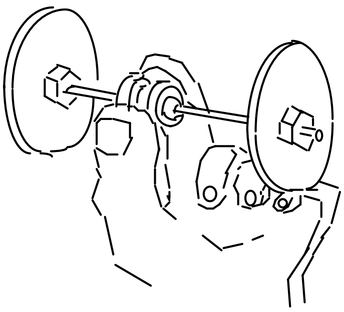
1.1. A set of wheels is an assembly of rotating or stationary elements linked to the chassis that helps the vehicle move forward.

In the diagram of the set of wheels hereof, there elements have not been designated. Name them.

The track width is the distance between the wheels of the vehicle. What is its value?

1.2. Carry out the set-up in accordance with the diagram and the indications given.

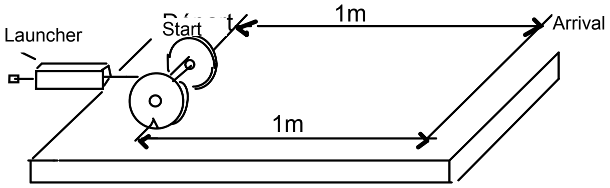
1.3 Move the ball bearings to the centre of the axle and place them gently between the index finger and the thumb (diagram 1), then rotate a wheel. Indicate all that rotates and all that doesn't.



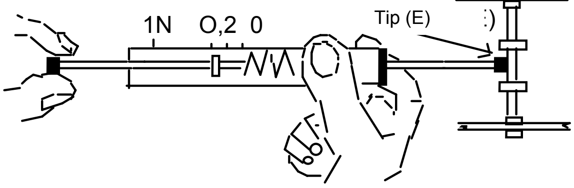
1.4 Hold the system by a single ball bearing (1) placed at the centre of the axle and rotate one wheel. What happens to the second ball bearing (2)? Why?

1.5 Carry out a second rotation and when the bearings are rotating, grip the ball bearings by pivoting your thumb and index finger. What change do you observe?
How do you explain this?

I2.Average velocity



Launcher's view from above



2.1 Mark a distance of 1 metre separating two lines on the table, which have to be subsequently erased. Place the notch of the wheel on the starting line.

2.2 Place the starter drive against the centre of the axle and stretch it until a maximum value of 0.2 N is displayed.

2.3 At the time of release, start the stopwatch and measure the time (t) of the path. Calculate the average velocity in meters per second and in centimetres per second.
Three trials will be performed where t1, t2, t3 are the times and V1m, V2m, V3m the average velocities. Justify the differences, if any.

2.4 Discuss this assertion: "a very short time after release, the wheels accelerate" true or false?

2.5 What happens to the set of wheels once the tip (E) is no longer in contact with the axle?

Mass and weight of the empty vehicle

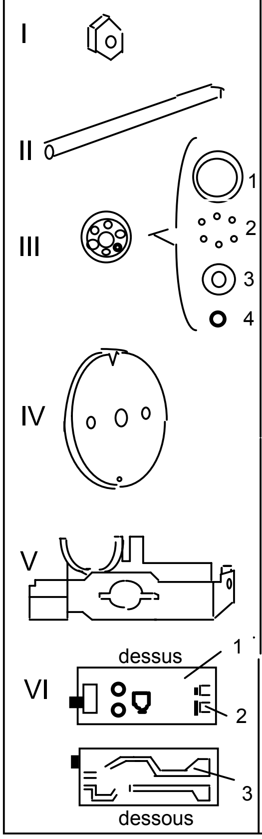
7 Assembly disassembly (set of wheels - chassis)

Objectives:
To prepare or reinvest the concepts of the chemical properties of materials.
To introduce and distinguish the concepts of mass and weight.

I1) Classification of materials and mass of elements

1.1 Copy and complete the table. For column 1, the parts will not be drawn. They will be identified by roman numerals I, II, III, IV, V, VI;

Two methods will be used to determine the mass. First make a manual estimate and then weigh with a scale.

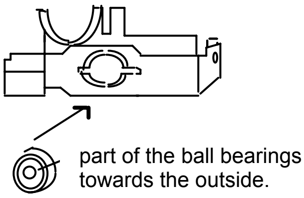
Drawing of the part	Name	Material	Unit mass Estimated/ Measured		No. of Parts	Total mass
						

1.2 Give the total mass measured M = mI + m II + m III + m IV + m V + m VI

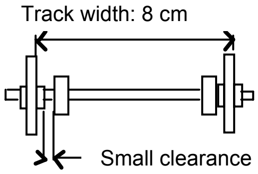
I2) Assembling a set of wheels on a half-chassis.

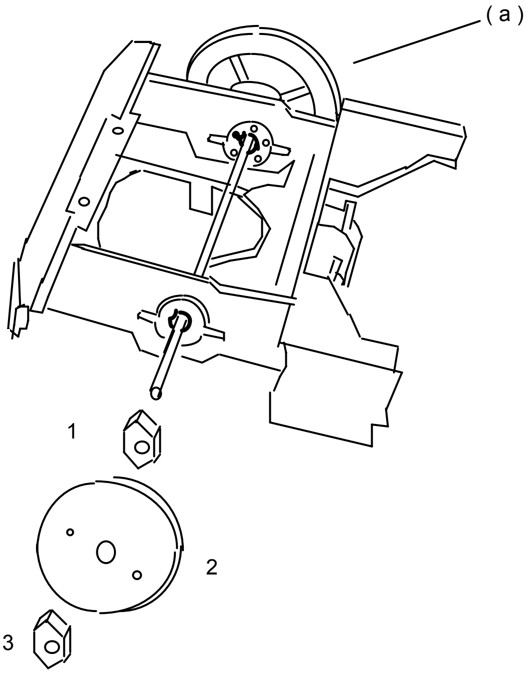
The chassis is the solid part on which the set of wheels is assembled. It is made up of two symmetrical parts that are fitted together using the printed circuit.

1.2. Insert the ball bearings in their housing with the protective skirt of the balls outside.



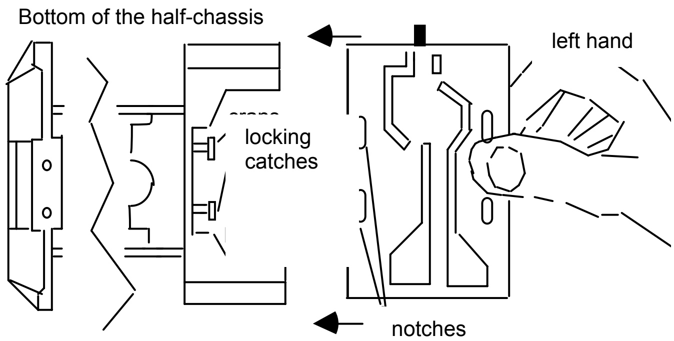
1.3. Turn over the half-cassis and thread the assembly (a) in the ball bearings
Then nut 1, the wheel 2 and the locknut 3.
f the track width is 8 cm (ensure this), the lateral clearance of the axle will then be small in relation to the ball bearings and the correct assembly.





1.4. Test for a proper assembly
Rotate the axle with the threaded rod,
the rotation must last 20 seconds for a strong impulse.
Does the half-chassis move? If yes, observe if a wheel is wobbling.

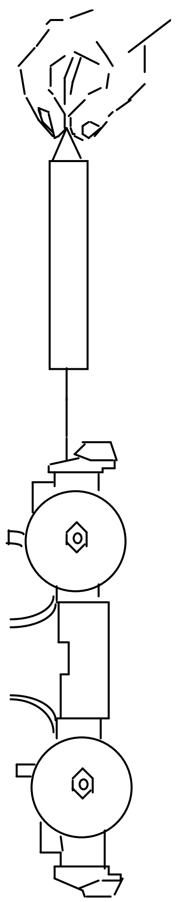
I2 Assembling the two half-chassis



3.1 Place the half-chassis upside down. Hold the printed circuit between the thumb and the index finger, then insert it into the guides until it stops against the notches.

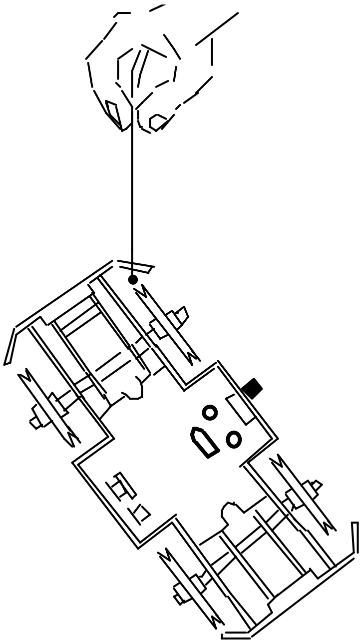
3.2 To engage the notches into the catches, lift the printed circuit with the index finger while holding the half-chassis with the left hand.

I3 Weight of the empty vehicle



3.1 Hang the vehicle from the dynamometer using the lug located under the bumper. Note down the weight.

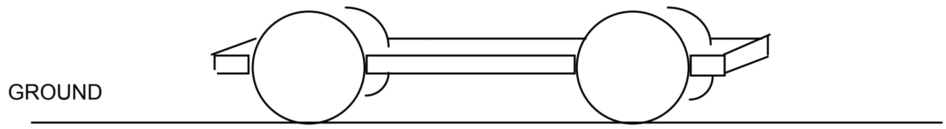
3.2 Take a loop of thread with quite a large knot at one end and pass it through the various retaining holes of the bumper. Lift the vehicle and examine the various positions that it takes. Deduce approximately from this the centre of gravity. Make a sentence to state the result.



3.3 Calculate the weight of the vehicle by using its mass and applying the formula that you will rewrite by specifying the units. Take the value listed below for G. P = m.g g = 10 ?/?

Compare with the value indicated on the dynamometer.

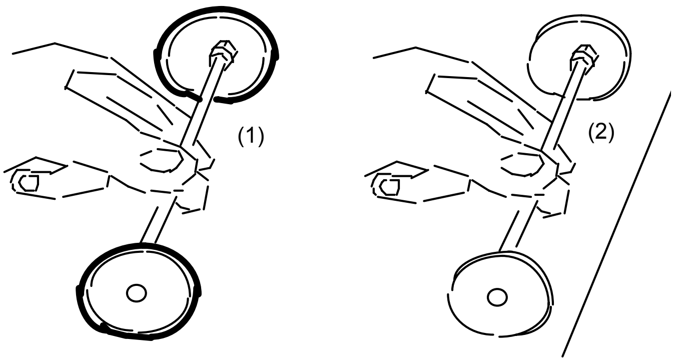
3.4 The vehicle may be represented by a diagram as below.
Reproduce it and draw the weight vector (P): point of application, line of action, direction, intensity. Select a scale and enter the notation of the vector Fx/y on the diagram beside its symbol.



8 Sliding, rotation of a wheel.

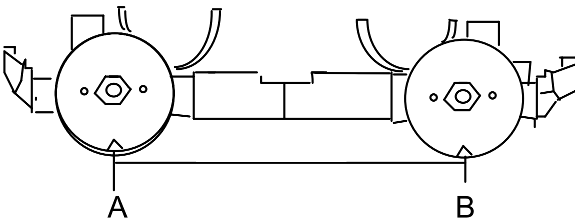
Preliminary concept of adhesion
Development of a wheel

Objectives:
To specify the modes of displacement of a wheel
To estimate the parameters affecting adhesion
To measure the development of a wheel and compare it with the theoretical value.
I1Displacement modes.



*Note: We show that the adhesion does not depend on the surface of the objects in contact.

1.1 Install the two sets of wheels. One with tyres (1), and the other without (2).
1.2 Take the axle between the thumb and the middle finger and jam it like with a brake. Move it forward with your hand and test the behaviour of each set on the table.
Copy the following sentences by completing them with the following words: insufficient, large, slips, rotates, material.
"The set of wheels (1) …….. while the set of wheels (2)…….. In this second case the adhesion is …………
We may conclude that, if we have pressed in the same manner, for (1 and 2), the adhesion* is more …….in (1) than in (2). It depends on ……… in contact."



2.1 Measure the approximate diameter (dv) of one of the front wheels.
Measure the approximate diameter (dr) of one of the rear wheels.

2.2. Draw on your sheet two reference points A and B separated by the wheelbase. (The wheelbase is the distance between the point of contact with the ground of the front wheel and the point of contact with the ground of the rear wheel).

2.3 Bring the reference notch of the wheels in coincidence with A and B (see drawing)

2.4 Move the vehicle forward without sliding so that each wheel makes one rotation. Locate on your sheet the new points A' and B' corresponding to one rotation of the front and rear wheel. Measure segments AA' and BB'. Why are they different?

2.5 Calculate the distance covered for each rotation of the front wheel (AA') and the rear wheel (BB') with pi = 3.14.

2.6 Compare the measured and calculated values. Note.

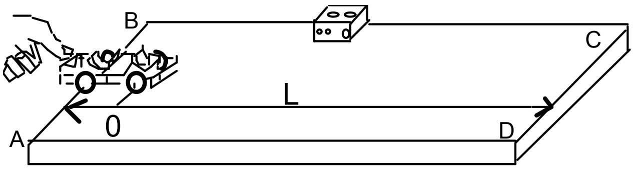
9 Application of rotation

Pressure between solids

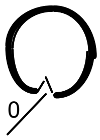
Objectives:

To show an application of rotation with good adhesion
To study the pressure between solids in the case of solid tyres and the ground.

I1) Measuring a length



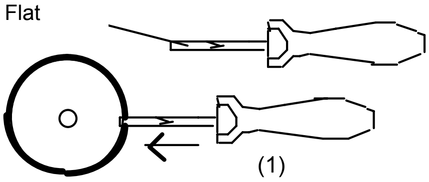
3.1 Install tyres on the front set of wheels to prevent sliding. Bring the rear set of wheels to the edge AB of the table and position the reference notch of the front wheel on the starting line passing through 0.

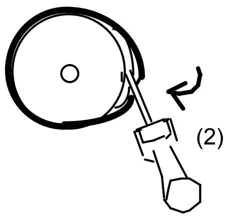


3.2 Slowly move the vehicle by pushing it, count the number (n1) of complete revolutions made and evaluate the fraction (n2) of revolutions required to reach the edge CD.

3.3 Knowing that the diameter of the wheel with the tyre is equal to D = 4.65 cm, and that pi = 3.14, calculate the perimeter P, deduce from this the length of the table
L = AO+OD (wheelbase AO = 10.5 cm.). Measure directly the length L' of the table with a ruler or a measuring tape. Which result seems more correct to you L or L'? Why?

3.4 To remove the tyres, thread the flat portion of the screwdriver shank between the tyre and the bottom of the rim (1), then turn the screwdriver towards you (2) by supporting it on the rim, the tyre comes off and it can then be removed by hand.





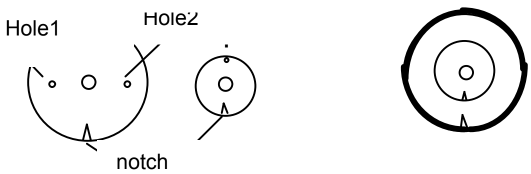
Record the marks left by the tyres of the vehicle on a paper when stopped.

Two precautions must be taken when recording the marks

a) The wheels of the vehicle must be locked

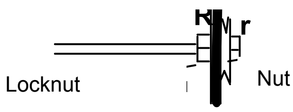
b) The vehicle must be place on the paper without applying any pressure.

Installing a double wheel

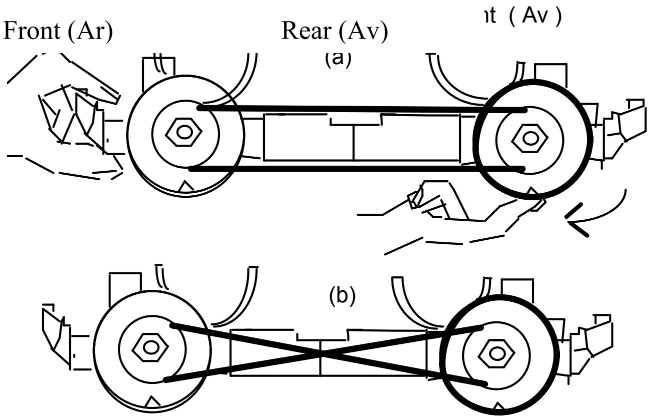


Bring the small wheel r on the large one R by aligning the notches. Then, hold where the lugs of (r) enter the holes 1 and 2 and the wheels are linked.

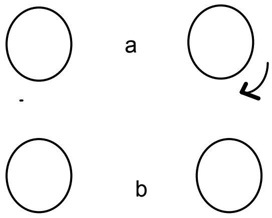
The four wheels will be installed on the axles according to the model indicated.



2.1 Connecting the wheels with the belt.



Connect the small wheels two by two with a belt as in a (direct belt) or as in b (crossed belt).
Raise the chassis with your left hand and drive the front wheel clockwise.
Reproduce the diagrams of wheels shown below and indicate the direction of rotation with a curved arrow.



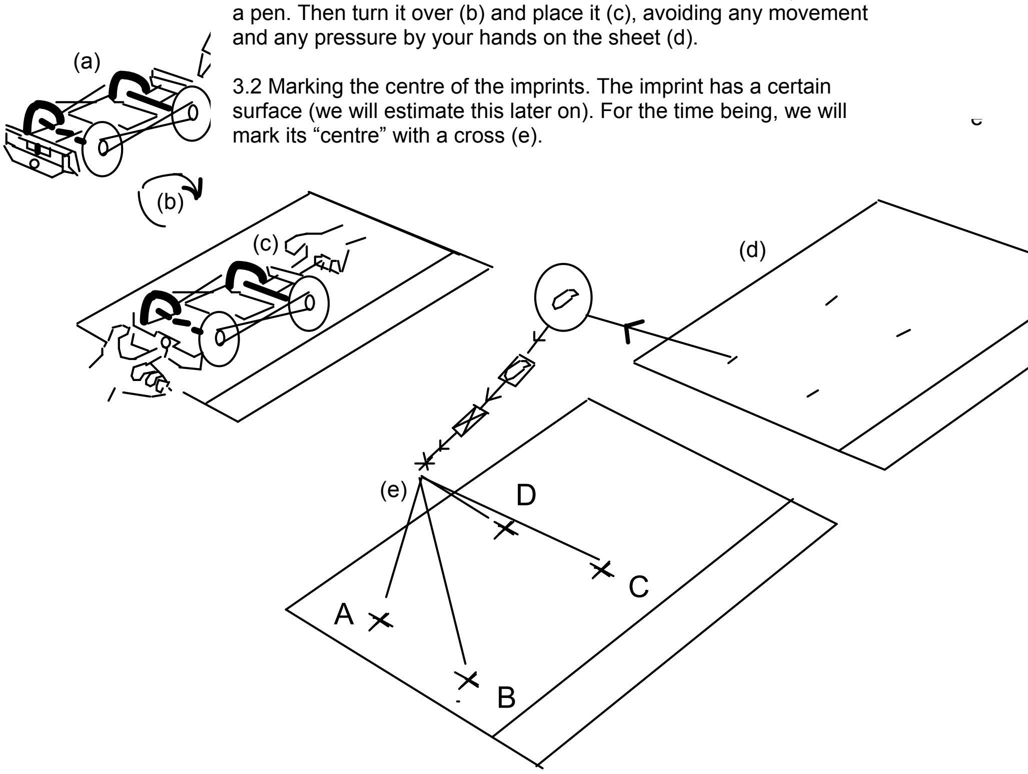
2.2 Locking the vehicle by one of the previous installatic

Place the vehicle on the table and push it lightly. Describe the phenomenon for (a) and (b) with a sentence. Which one prevents the vehicle from moving forward? Why?

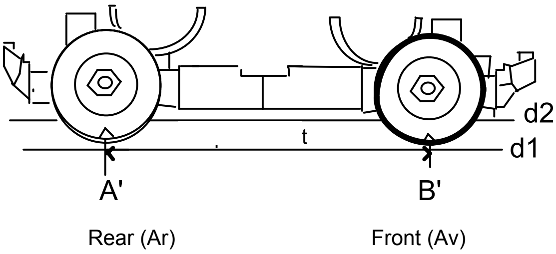
2.3 Imprint taking

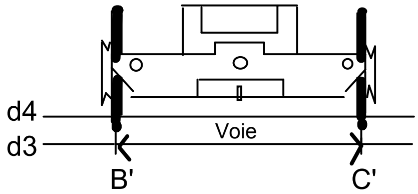
3.1 Place the vehicle upside down (a). Mark the top of the tyres with a pen. Then turn it over (b) and place it (c), avoiding any movement and any pressure by your hands on the sheet (d).

3.2 Marking the centre of the imprints. The imprint has a certain surface (we will estimate this later on). For the time being, we will mark its “centre” with a cross (e).



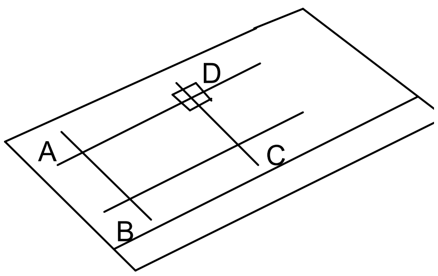
3.3 Examine the drawing below that indicates the wheelbase and the track width. Then write a sentence to define each of these terms.





3.4) Using the crosses A, B, C, D, draw the lines d1, d2, d3, d4 on your paper with a pencil. Measure the lengths AB and CD on the drawing and compare them with A'B' and C'D' on the object.

3.5) Measure the contact area with a graph paper.



5.1 What is the approximate surface area of the graph paper labels?

Glue the pieces of graph papers as in D, by aligning them with the lines d1, d2, d3, d4.

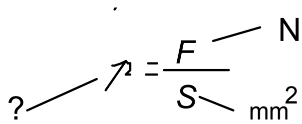
As previously, turn the vehicle over, mark the tyres with ink. Then place it carefully on the labels at A, B, C, D.

5.2 Measure the approximate surface of the imprints SA, SB, SC, SD in mm2

5.3 Do the imprints seem equal to you? If not, classify them in descending order.

3.6) Pressure.

6.1) For each imprint, calculate the pressure at a point by carrying out the operation below.



We will recall that it is the weight P of the vehicle that is applied on the paper. It is reasonable to make the following hypothesis: considering the symmetry of the object, each wheel will be regarded as bearing one-fourth the weight. Therefore F = P/4 p = N

$$F = \frac{P}{4} \qquad P= \quad N$$

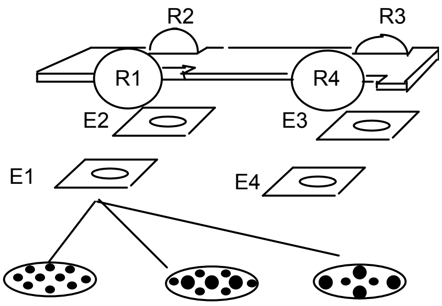
6.2 What can be said of the pressure at a point of the tyre surface in contact with the ground?

6.3 We load the vehicle with a mass M = kg. Note down the new imprints. Compare them with those of the empty vehicle.

6.4 If we double the weight of the vehicle, can we simply conclude about the value of the pressure at each point of the ground? If yes why, if no why not?

3.7) Force and pressure diagrams on the paper

We can schematically represent the vehicle as below. The imprints on the labels have been enlarged for clarity. Reproduce only the imprints E1, E2, E3, E4.



7.1 Mark on these the force vectors (point of application, line of action, direction) exerted by the wheels of the vehicle. You will have to select a scale and give the notation of vectors Fx/y next to their symbol.

7.2 Select from among the representations of the pressure for imprint E1, the one that seems most suitable for the situation to you. Reproduce it, describe it and justify your choice.

We will recall that the pressure at a point can be represented by a disk of a radius that is la valeur proportional to the value of the pressure at this point.

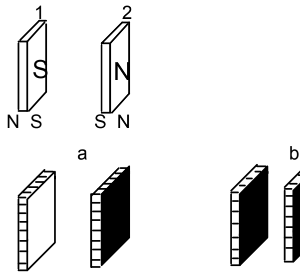
10 Magnetic catapult and description of the movement

Principle of reciprocal actions (P.R.A)

Note: The magnets are very delicate. They must be handled with care.

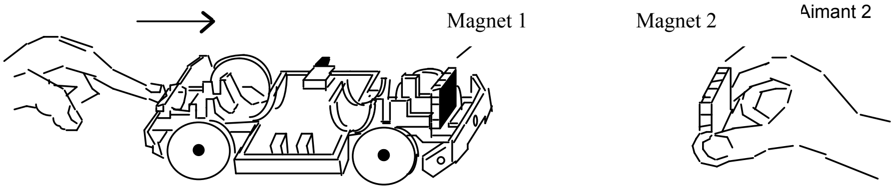
Objectives:
To describe the movement
To implement a remote interaction
Analogy and difference with a calibrated catapult.

I1) Movement



1.2 We will recall that a magnet has two poles: a north pole (black) and a south pole (white).
1.3 Place the magnets as in (a) and (b) then copy and complete the sentences below:
"When a south pole faces a .... pole (situation a), the magnets ...."
"When a north pole faces a .... pole (situation b), the magnets ...."

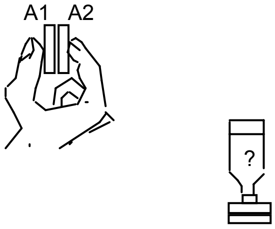
1.1 Install one of the magnets (1) between the bumper and the curved support in front of it. Push the vehicle lightly with the index finger of the right hand. Hold the second magnet (2) with your right hand so that two similar poles face each other.



1.4 From the moment the vehicle leaves the finger, describe the movement of the chassis.
When the vehicle approaches the magnet (2), how does the velocity of the vehicle vary?
Compare the direction of the force acting on (1) and the direction of displacement of the chassis
by completing the sentence: "The force F 2/1 is directed from .... to ......, whereas the chassis moves from ..... to ....."
1.5 What can be said of the velocity at the instant when magnet (1) is as close as possible to magnet (2)?
1.6 Describe the movement after this instant.

I2) Remote interaction

2.1) Static effect



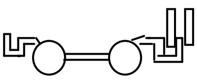
1.1 Hold the two magnets A1, A2 placed back to back and in contact between the thumb and index finger. Estimate the order of magnitude of the intensity of forces acting between the two magnets, by mere touch.

1.2 To have an idea of the order of magnitude, we perform the following experiment. We hold the magnets one against the other by placing on them a bottle filled with a certain amount of water.
We verify that if the bottle contains 1l, the magnets move. With 1.5l they remain still. Deduce from this an upper limit for the intensity of forces.

Actual situation   Study situation

1.3 For both situations, we will draw a diagram of the interaction (points of application, line of action, direction). We will select a scale knowing that F???. Note down the vectors Fx/y, next to their symbol.

2.2 Dynamic effect

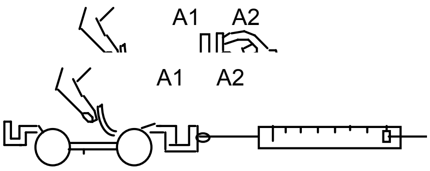


2.1 Following a release, we suppose that the bumper of the car
comes in contact with magnet 2 (See diagram). Give an order of magnitude of the interaction at this instant. We specify that the intensity of interaction reduces with the distance that separates

Actual situation   Study situation

2.2. On the study situation, we will draw a diagram of the interaction. What is the only difference compared to the static situation of paragraph 2.1?

I3 Magnetic and calibrated (dynamometer) catapult



3.1 Lock the vehicle in the position shown with the magnets facing one another. Release it, while maintaining A2 fixed. Describe the movement? Measure the distance traversed.

3.2 Arm the catapult with maximum intensity. Apply it to the vehicle as show in the drawing.
Describe the movement from the time when the catapult is released. For how much time does the catapult act on the vehicle? What can be said of the intensity of force during this time?

3.3 Measure the distance traversed.

3.4 What analogies and differences do you see between the two experiments?

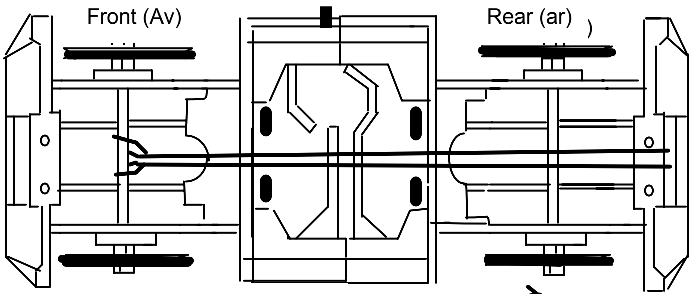
11 Elastic and manual release propulsion

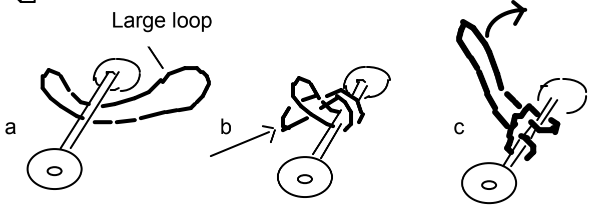
Drive wheel, passive wheel; ground and wheel interaction

Objectives:

To examine an accelerated and decelerated motion
To distinguish between a drive wheel and a passive wheel
To implement the principle of reciprocal actions in a contact interaction
To carry out comparative tests for throws.

I1) Propulsion
Installing the elastic.



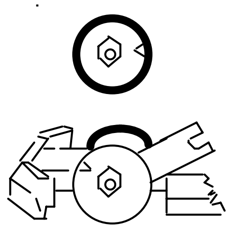


1.1 Assemble the chassis and the set of wheels as show in the figure hereof. Then, place it upside down. We will install the rubber band.

1.2 Front wheel drive. Depending on how we install the rubber band on the front axle, we will have front or rear-wheel drive. For a front-wheel drive, follow the following instructions:

a) Slide the rubber band under the front axle and make two unequal loops.
b) Insert the large loop into the small one and pull.
c) Attach the end of the large loop to the rear lug located under the bumper.

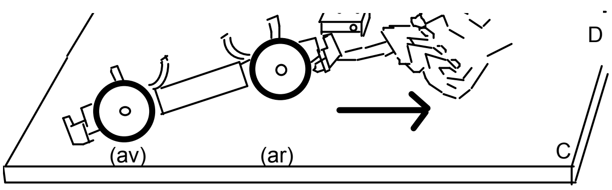
1.3 Study of the movement (Vehicle upside down)



3.1 In what direction must the front wheel be rotated to stretch the rubber band? (It may be necessary to press on the rubber band to ensure a slight tightening on the front axle)

3.2 Mark the position of the notch on the wheel and make ten revolutions in the direction of the rubber band's winding. Lock it with an 8 mm wrench placed on the inside nut. Release the wheel by removing the wrench. For approximately how much time does it rotate? What is its movement? Specify the two phases of the latter in function of the state of the rubber band.

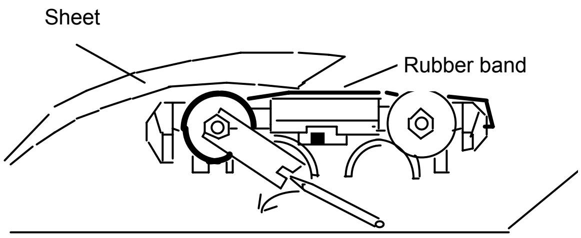
1.4 Study of the movement (Vehicle on the spot).



4.1 By pressing under the rubber band and the bumper with the index finger, raise the rear set of wheels of the vehicle and bring it to the edge of the table. Count the number of revolutions made by the front wheel. Did it slide during the movement from left to right?

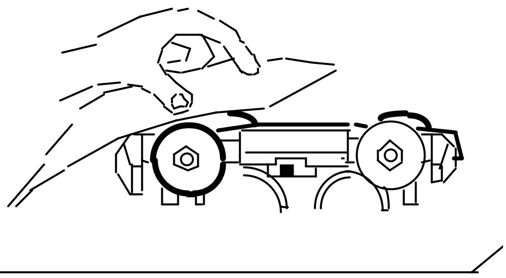
4.2 One student prepares to block the vehicle on the left of the table. Once he is ready, place the rear wheels and remove the index finger. Describe the movement of the chassis. Estimate the time and calculate the average velocity, one digit after the decimal place.

I2) Drive wheel (M) and driven or passive wheel (P) The vehicle upside down.



2.1 With the vehicle upside down, stretch the rubber band by making one or two rotations of the front wheel, then lock it with the wrench as shown in the drawing.
Place a slightly thick sheet of paper (Bristol type) on the front wheels and release the wrench by moving it with a pencil, for example.

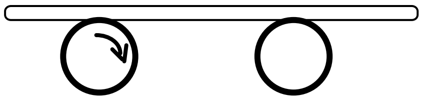
2.2 Describe in three short sentences what you observe for the sheet and the front and rear wheels. Reproduce the tyres and complete with a curved arrow to indicate their direction of rotation.



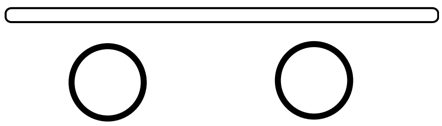
2.3 Repeat the experiment, stretch the rubber band (two to three rotations) but block the system by pressing on the sheet with the index finger and the thumb (see diagram) on the front wheels. Release the pressure gradually, the scrolling of the sheet may be controlled and observed in slow motion. What drives the front wheels? What drives the rear wheels?

I3 Contact interaction diagram (wheels (M, P), paper.) The vehicle upside down.

Actual situation



Study situation



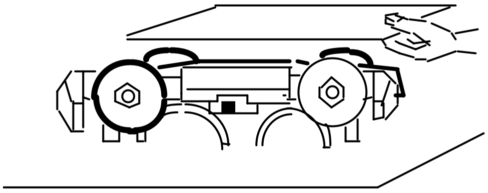
3.1 Instructions

To make a diagram of the interactions between the wheels and the sheet, we take a sufficient thickness of the paper to make things clearer. The order of magnitude of the interactions will be taken as approximately 1N for the (drive wheel, sheet) and 0.5N for the other interaction.

3.2 On the study situation, indicate for each element, the point of application, the line of action and the direction of forces. We will select a scale in function of the information in paragraph 3.1. Note the vectors Fx/y next to their symbol.

3.3. Apart from the intensity, what difference(s) do you observe regarding the forces acting on the drive wheels and passive wheels?

I4 Driven (M) or passive (P) wheels. Diagram of forces acting on the wheels.



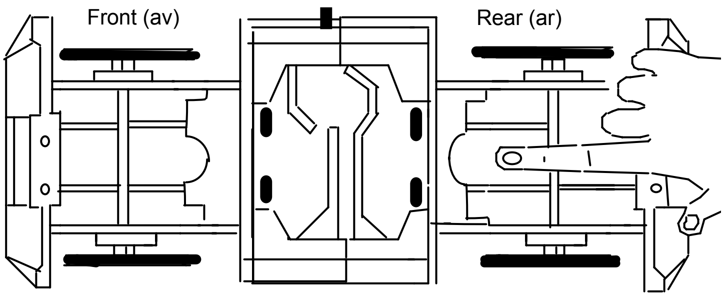
4.1 Place the sheet or the plate on the overturned vehicle. Nothing moves if the table is horizontal.
Move, with your hand, the plate from left to right, the wheels begin to rotate.

4.2 Make a diagram of the front and rear wheels; indicate their direction of rotation by marking an arrow at the end of the arcs.

4.3. We suppose that the sheet exerts forces of same intensities on both wheels (0.1 N). Mark on the previous diagram the vectors Ff/Rav and Ff/R ar. Indicate what these forces have in common apart from the intensity and the line of action.

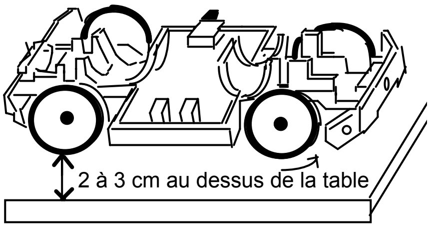
I5) Manual throws with stored energy before release
In the wheels (rotation - R)
In the vehicle (travel -T)
In the chassis (T) and the set of wheels (R)

5.1) Rotational kinetic energy stored in the wheels



1.1. Vehicle upside down.
Rotate the set of rear wheels and front wheels with your index finger. Measure the durations of rotation of the front and rear wheels (t av, t ar).

1.2 Vehicle in place



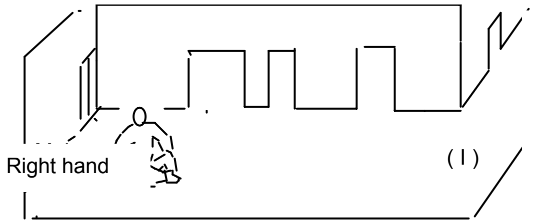
2.1 Turn the vehicle over; hold it 2 to 3 cm above the table. Rotate the set of rear wheels as previously. The manner in which it will be released will have an impact on the effect observed. When the vehicle is about 1 cm from the table, let it drop. Measure the average distance travelled D1.
(at least three trials will be carried out).

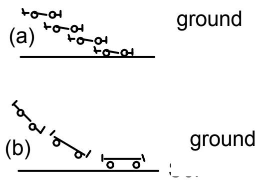
2.2. Proceed as earlier, but release the two sets of wheels in the same direction. Measure the average distance travelled D2.

2.3 Release the set of wheels in the opposite direction. Measure the average distance D3.

2.4 Why don't we always get the same result during the trials?

5.2 Translational kinetic energy stored in the vehicle.



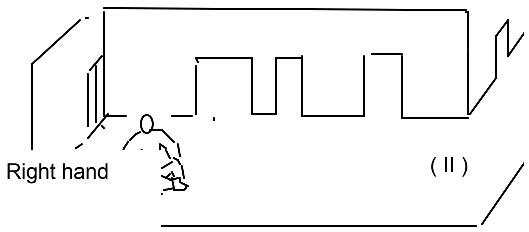


2.1 Position yourself in a hall or a corridor.
Crouch down as in the diagram (I). The vehicle is raised and does not touch the ground. We consider two phases in the movement: before contact with the ground and after contact with the ground. Two simple movements (a) and (b)

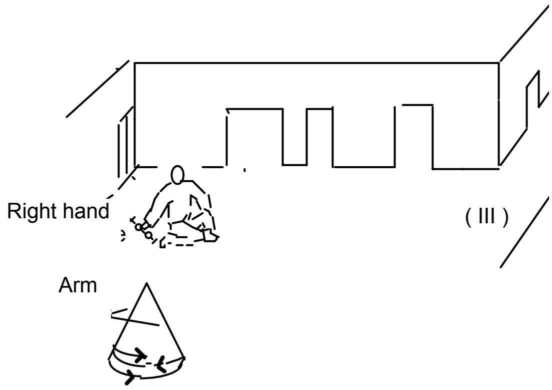
are possible during release, which ones?
Try the two types of releases (if one wants a rectilinear path for the vehicle, the arm as well as the hand must remain in a vertical plane).
Describe the movement of the arm (a) and the movement of the arm and the wrist (b). Which one is easier to perform? Why?

2.2 Measure the distances travelled La and Lb and the corresponding times ta and tb. Calculate the average velocity in each case.

5.3) Translational energy stored in the chassis and (travel, rotation) in the wheels



3.1 We adopt another technique for release, the vehicle is always in contact with the ground, diagram (II).
Describe the movement of the chassis and the wheels during the release.
What can be said of the movement after release?



3.2 The third technique for release consists in making to and fro movements with the arm like in the case of a swing and to bring the vehicle in contact with the ground at the bottom of the trajectory only during the forward movement.
Describe the movement of the chassis and the wheels during the release
What can be said of the movement after release?

3.3 From among the three previous techniques, which one seems to permit (theoretically) a release that goes furthest? Why?

12 Interaction between the drive wheel (dw) / and the ground on starting and braking

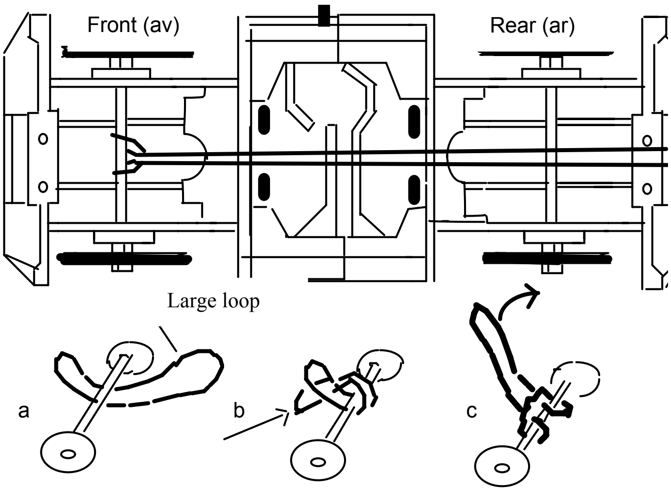
Objectives:

To implement the principle of reciprocal actions on the drive wheel in starting and braking situations

Diagram of the two cases.

I1) Interaction (drive wheel (dw) ground (g))

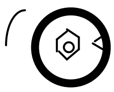
A) Fixing the elastic on the front wheel



1.1 Assemble the chassis and the set of wheels as shown in the diagram hereof. Then, place it upside down. We will install the rubber band.

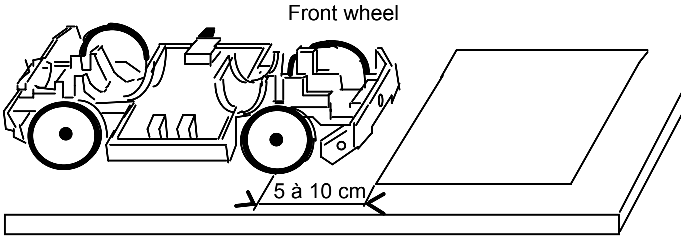
1.2 Front-wheel drive.
Depending on the manner in which the rubber band is installed on the front wheel, we will have front or rear-wheel drive. For front-wheel drive, follow the following instructions:
a) Slide the rubber band under the axle and make two unequal loops.
b) Insert the large loop in the small one and pull
c) Hook the end of the large loop to the rear lug located under the bumper.

1.3 Study of the movement (vehicle upside down)



3.1 In which direction must the front wheel be rotated to stretch the rubber banêtre may be necessary to press or pull the rubber band to ensure a slight tighteningge de the front axle and to thus initiate the possibility of winding on the axle. l'axe).

B) Interaction between drive wheel / ground on starting



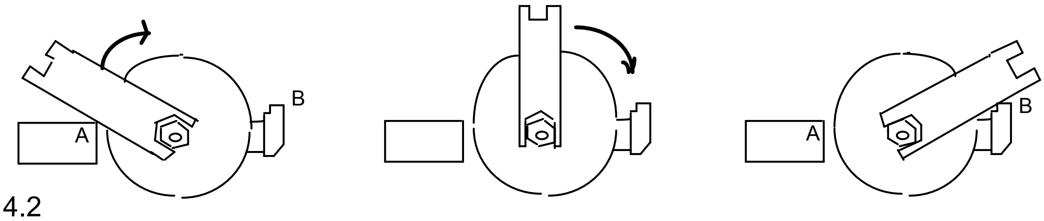
4.1 Place a sheet on the table.
"Wind up" the rubber band by winding it over 5 turns on the front axle. Position the vehicle as shown in the diagram and release it.
Observe the sheet during the various stages of the passage of the vehicle. Copy and complete the sentence below with the list of words provided.

"When the wheels ….. front come to the sheet, they exert a ….. action. On the one hand, they …. vertically on the sheet; on the other they …… tangentially. The effect of this second action is to ….. the sheet to …. On the table. Then the rear wheels ….. interact with the sheet at the same time as the front wheels. Then, under the effect of the table, and the second set of wheels, it …."

(Press, drive, act, simple, double, slide, left, immobilise, move back, passive)

C) Interaction between drive wheel / ground on braking.

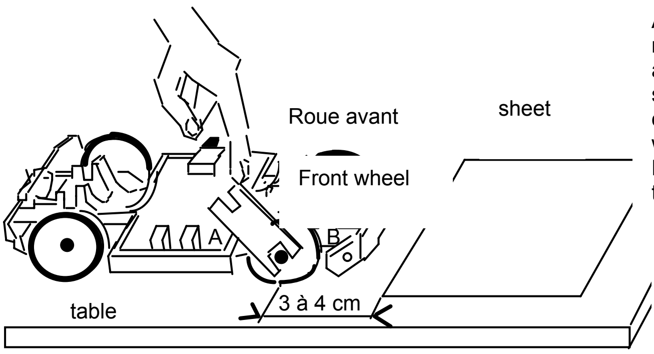
Brake principle



4.2

The spanner wrench will be used as a brake. For this, we install it on one of the nuts of a drive wheel, as shown in the diagram (outside it); better reliability is obtained by positioning it on an internal nut. Driven by the movement of the wheel, the wrench initially at A comes against a stop at B, blocking the rotation. Approximately by what fraction of a rotation can the wheel rotate when the wrench goes from A to B?

4.3 Experiment



After having "wound up" the rubber band by about five turns around the axle, set-up the situation as shown in the diagram hereof and block the wrench with the index finger. Remove the finger and observe the phenomenon.

3.1 Describe the movement of the vehicle when the wrench goes from A to B.
What can be said of the movement just after the time of contact of the wrench at B?

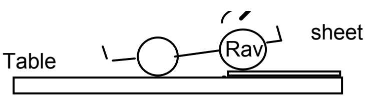
3.2 Copy and complete the following sentence with suitable words.

"When the set of front wheels ….. gets blocked on the sheet, it exerts a double action.
It presses and it pushes … the sheet. In this case, the movement of the vehicle and the sheet are in the ……. direction.

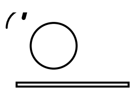
4.4 Diagram

4.1 4.1. We will represent the two situations with diagrams.

1.1 First case, starting ıge le



Study situation



We will represent only the propulsion interaction in the study situation.
The action of the weight of the wheel must not be shown.
Complete:
Based on ….. principle, if the wheel drives the sheet from right to left, then the sheet ….. the wheel from ….. to right.

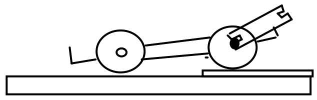
Give the notation of the two vectors corresponding to this sentence. What is the relation that relates these two vectors?

We suppose that the order of magnitude of the intensity of interaction is: 0.5 N

Select a scale and draw the two vectors on the study situation.
Mark its notation next to each vector.

1.2. Second case: braking

Actual situation



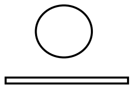
Make a sentence to represent the interaction of the drive wheel that brakes and the sheet.

Give the notation of the two corresponding force vectors.

Study situation

Drive wheel

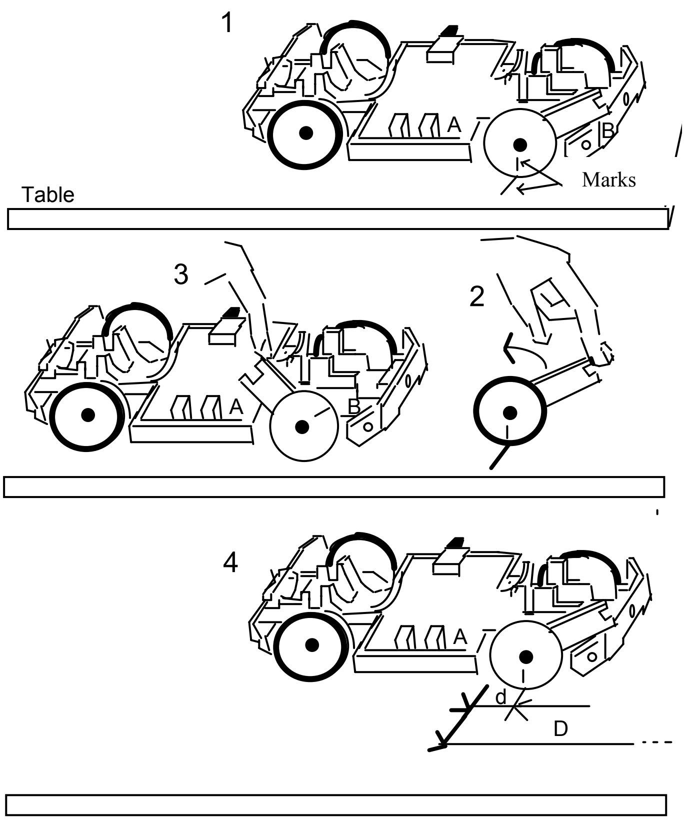
sheet



We suppose that the intensity of interaction is equal to 1N.
Select the same scale as the one for starting.
Mark the two vectors and their notation on the study situation.

I2 Braking distances: (dry and damp ground simulation)

2.1 Dry ground: The surface of the table



(see drawing 1)

1.1 “Wind up” the rubber band by about five turns. Lock the axle by placing the braking wrench between the wheel and the chassis, on the inner nut.
Make two marks with a pencil, one on the wheel and the other on the table.

(See drawing 2)

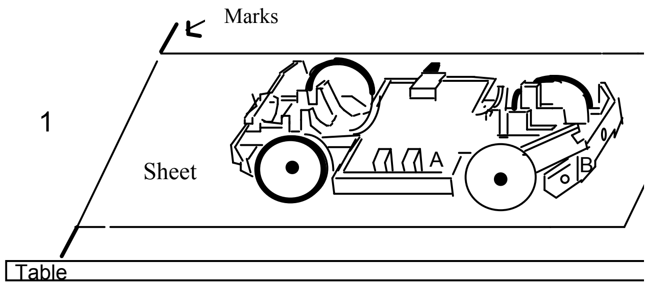
1.2. Hold the end of the wrench with your index finger (2). Bring it from B to A (3). The vehicle moves back. Remove your index finger.

1.3 (See drawing 4)
The vehicle accelerates then brakes.
Measure the braking distance d.

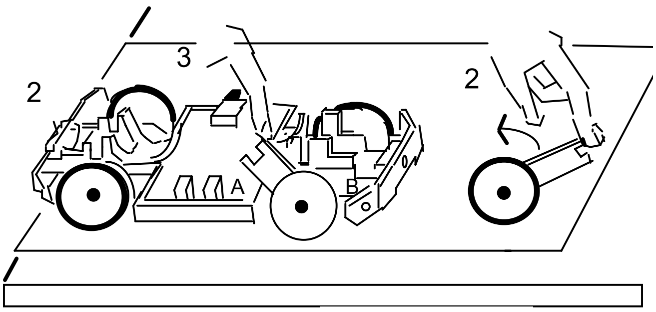
Make ten consecutive trials with a constant rubber band tension. For this, you only need to repeat procedure (2) then (3) from the new stopped position of the vehicle.
Measure D, Calculate D/10 and compare this result with d. Note.

2.2 Simulation of damp ground

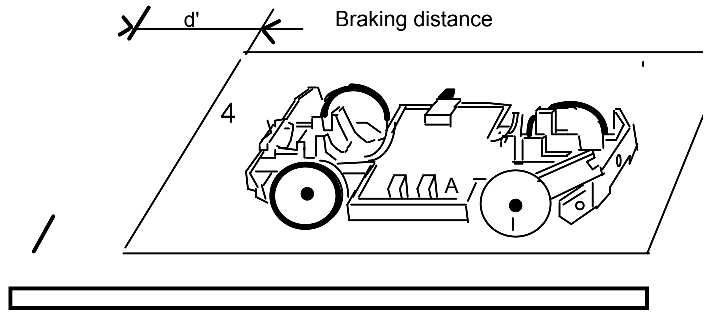
When the road is wet after rain, a sort of film between the ground and the wheel is formed when the wheel passes. This very dangerous phenomenon constitutes "aqua planing". We will simulate this by placing a paper between the table and the tyres.



2.1 (drawing 1)
“Wind up” the rubber band by about 5 turns. Lock the motor axle with the wrench placed between the wheel and the chassis.
Place a sheet on the table.
Mark its position with a light line using a pencil.
Place the vehicle at its centre.

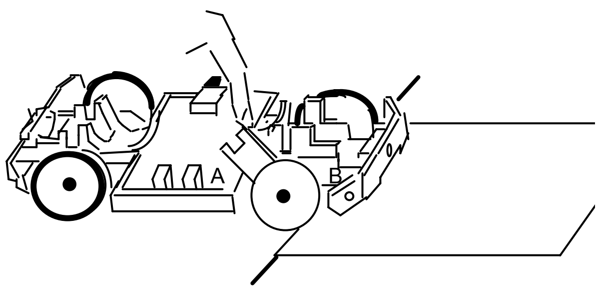


2.2 (drawing 2)
Hold the end of the wrench with your index finger (2) and bring it from B to A. The vehicle moves back.
Remove your index finger (3).



2.3 Measure the braking distance d’ by taking the average of three trials d’1, d’2, d’3.
Compare d’a and d and say how many times the braking istance has been increased on wet ground.
What is the practical consequence of this?

2.3 Experiment



3.1 Repeat the previous experiment by placing the sheet almost touching (5 mm) the drive wheels.

Describe the movement of the sheet.
Explain this by considering the two phases of movement of the vehicle.

13 Sliding   Skidding

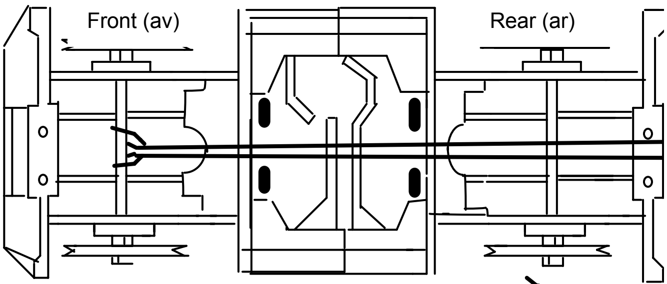
Adhesion, sliding on an inclined plane.

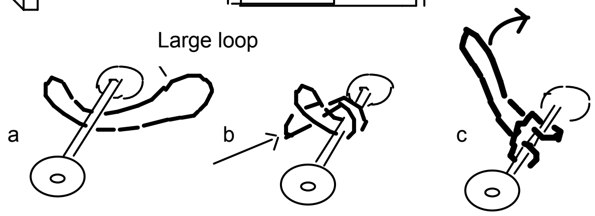
Objectives:

To specify the terms sliding, skidding
To examine the factors on which the adhesion depends (analyse an experimental procedure)

I1) Sliding skidding
A wheel skids when it rotates without advancing.

1.1 Fixing the elastic on the vehicle **upside down**.





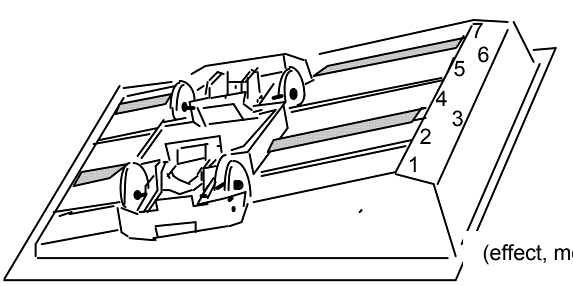
1.1 Assemble the chassis and the set of wheels as shown in the diagram hereof. There are no tyres. Then, place it upside down.
Install the rubber band.
1.2 Front-wheel drive.
Depending on how the rubber band is installed on the front axle, we will have front or rear-wheel drive. For a front-wheel drive, follow the instructions below:

a) Slide the rubber band under the front axle and make two unequal loops.
b) Insert the large loop into the small one and pull.
c) Attach the end of the large loop to the rear lug located under the bumper.

1.2 First experiment

Turn the vehicle over and "wind" it with 5 turns of the elastic. Lock the motor axle by hand, place the vehicle on the table and release the axle. What is the distance covered by the vehicle?
Describe the two phases of movement observed for the front and rear wheels.

1.3 Second experiment



3.1 The surface of the inclined plane includes 7 numbered tracks (see diagram).
Place the vehicle across so that the wheels are on tracks 1 and 5.
Complete the sentence using suitable words
Under the effect of its …. the vehicle begins to ……, there is dynamic ………, it slides ……… we say that it ……….

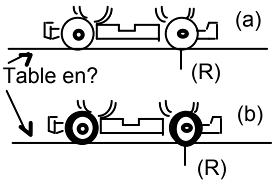
(effect, motor, movement, weight, hurtles down, skids, transverse

What happens if the wheels are placed on tracks 3 and 7? Reply with a sentence similar to the previous one.

I2 On what does the adhesion between two objects depend?

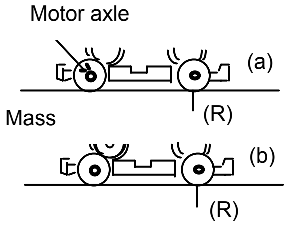
From the various factors that we will be examining, when one factor is being tested the others must be maintained constant. Intuitively, we could think that the nature of the materials, the intensity of the force that they apply on one another and the contact area play an important role.
There is adhesion between two objects when they are not sliding against each other.

2.1 Nature of the materials in contact?



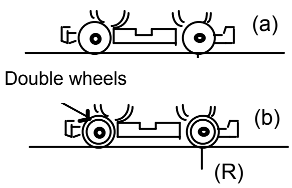
1a The wheels are without tyres. “Wind up” the rubber band by five turns.
Lock the axle with the hand and place the vehicle on the mark (R).
Release and measure the distance travelled (L1).
1b The wheels are fitted with tyres. “Wind up” the rubber band by five turns.
Lock the axle with the hand and place the vehicle on the mark (R).
Release and measure the distance travelled (L’1).
1c Has the weight of the vehicle changed between (a) and (b)?
The nature of the materials in contact? The contact surface between the materials? In which case is adhesion the largest?

2.2 The intensity of the force that the materials apply one against the other?



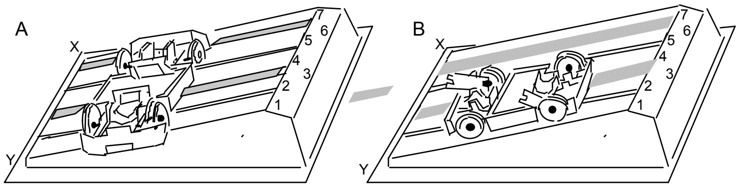
2a The wheels are without tyres. “Wind up” the rubber band by five turns.
Lock the axle with the hand and place the vehicle on the mark (R).
Release and measure the distance travelled (L2).
2b The wheels are fitted with tyres. “Wind up” the rubber band by five turns.
Place a mass of 200 g in the cradle above the motor axle.
Release and measure the distance travelled (L’2).
2.1 Has the weight of the vehicle changed between (a) and (b)?
The nature of the materials in contact? The contact surface between the materials? In which case is adhesion the largest?

2.3 The contact area between two materials



3a The wheels are without tyres. “Wind up” the rubber band by five turns.
Lock the axle with the hand and place the vehicle on the mark (R)
Release and measure the distance travelled (L3).
3b Double wheels of the same diameter are installed on the axles.
“Wind up” the rubber band by five turns. Place the vehicle on the mark.
Release and measure the distance travelled (L’3).
3.1 Has the weight of the vehicle changed between (a) and (b)?
The nature of the materials in contact? The contact surface between the materials? In which case is adhesion the largest?

I3 Inclined plane and adhesion



3.1 Proceed to experiments A and B, with tubeless dual wheels. Tracks (A 1,5) and (B 1,4). Bring the track plane to horizontal by raising it from the X, Y edges. Place the vehicle and bring XY back in contact with the table.

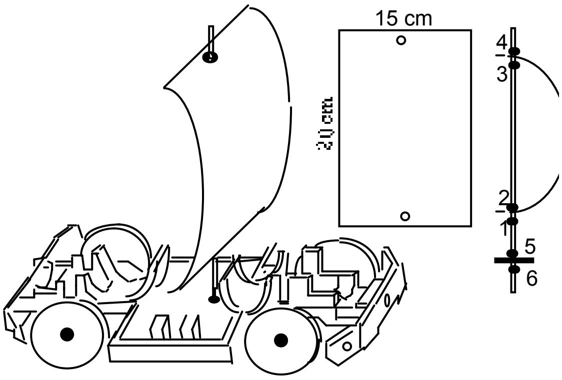
3.2 Is there sliding? Is there a difference between A and B? Compare with (I 1,3)and (I 2,3.1) Conclude.

14 Propulsion by sails, propeller or ejection of material.

Objectives

To bring into play an interaction where one of the elements is invisible (air)
To estimate the order of magnitude of the intensity of the interaction
To make a diagram
To differentiate between these modes of propulsion.

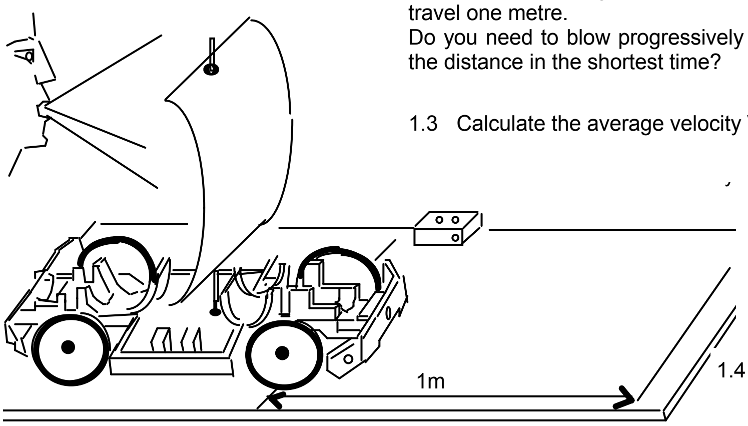
I1) Propulsion using sails.



1.1. Cut out a rectangle of 15 cm x 20 cm from a sheet. Make two holes of 4 mm diameter with a punch. Fix the sheet on the threaded rod using nuts (1,2,3,4).
The mast is plugged into the hole of the printed circuit and locked by nut (5) and locknut (6).

1.2 Breathe in deeply so that you fill your lungs fully with air. Then blow in a single blast. Measure the time required to travel one metre.
Do you need to blow progressively or at one go to traverse the distance in the shortest time?

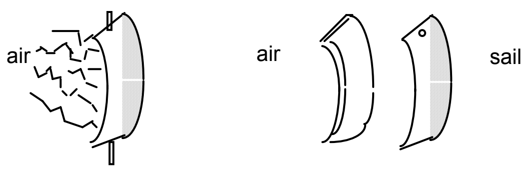
1.3 Calculate the average velocity Vm.



1.5 What modification (s) does the exhaled air undergo when it comes in contact with the sail?

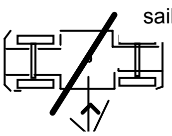
1.4 Schematic representation of the interaction (Air, sail)

Actual situation   Study situation



It is a surface interaction. We will simplify by representing the air as a layer having the shape of the sail. Set an order of magnitude for the intensity of interaction at an instant:
F = ? N (you may compare the effects with those caused by a catapult to get an idea).
Draw the line of action. Specify the two "points of application". Indicate the scale and draw the two force vectors Fx/y next to their symbol.

1.6 The sail is at 45° (refer to the diagram) in relation to the axles

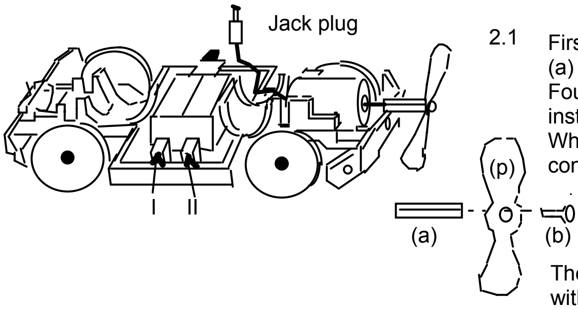


Blow in the direction of the arrow

What modification does the air undergo in its movement? Measure the displacement for one exhalation. Copy the diagram and indicate the direction of displacement of the vehicle in Red.

I2 Propulsion using a propeller

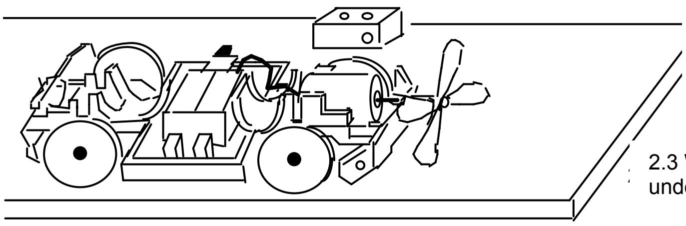
Preliminary note: Depending on the condition of the battery, the adjustment of the play on the axles and in function of the rim of the wheels and the condition of the table, the propulsion may require two, three or even four blades.



2.1 First, we install only one blade (p) on the spacer (a) using the retaining screw (b).
Four elements of the cylindrical cell (U=1.5V) are installed in series in a connector.
What is the voltage at the terminals of the connector?

The terminals of the connector are connected without forcing to the legs I and II of the chassis and the jack plug in one of the sockets of the printed circuit.

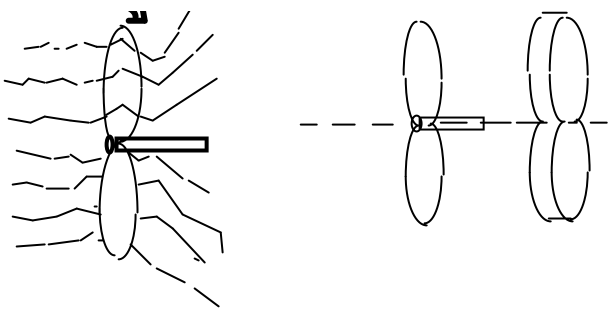
2.2 The vehicle must be placed on a smooth and horizontal surface of a table.



Measure the time t that is required for a distance travelled of 1 m.
Describe the movement.
Calculate the average velocity.

2.3 What modification does the air undergo upon contact with the propeller?

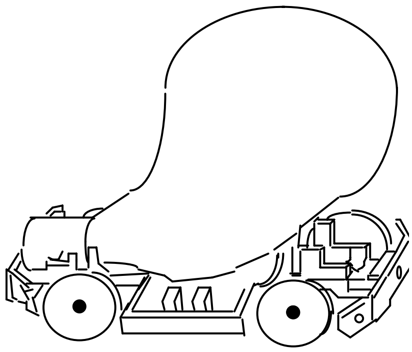
2.4 Interaction diagram.



This is a surface interaction. We will simplify by representing the air as a layer having the shape of the propeller.
This air is obviously driven on the one hand in rotation and on the other hand due to the tilt of the blade, it is pushed backwards.
For the representation we will consider only the latter effect.
This distributed action will be represented on the axle (the line of action has been shown).
We suppose that the vehicle is moving from right to left.

Set an order of magnitude for the intensity of interaction F = ? Specify the scale and mark the two vectors Fx/y next to their symbol.

I3) Propulsion by ejection of matter (Air).

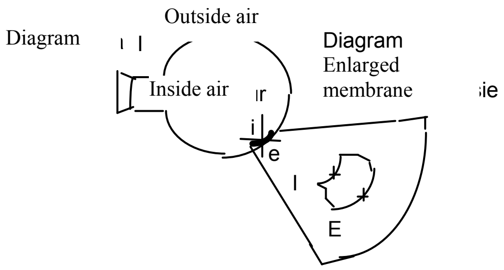


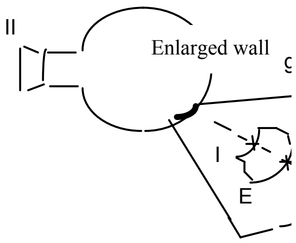
3.1 Fit the end of the rubber skin balloon on the blower tube. Inflate the balloon either with a pump (+ plug with a hole, + valve and union) or with the mouth.

3.2 Close with the solid plug. Estimate the volume of air trapped inside. Give an order of magnitude for the mass of air and the gas pressure. Place the tube on the clamps of the chassis (see diagram).

3.3 Remove the solid plug and measure the distance travelled as well as the time of travel. Calculate the average velocity. Describe the movement.

3.5 Two representations of the same situation.





The inside and outside air is at different pressures.
Represent the pressure at a point inside the membrane I and at a point outside the membrane E by a disk (Diagram I).

On the diagram II, indicate the force vector of the inside air/the membrane (aI/m) and outside air/the membrane (aE/m) for the same points.

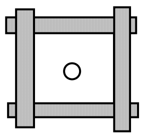
15 Displacement on a circular trajectory.

Objectives:

To define a frequency of rotation
To define a linear average velocity
To examine the problem of wheels linked internally and externally in relation to adhesion.

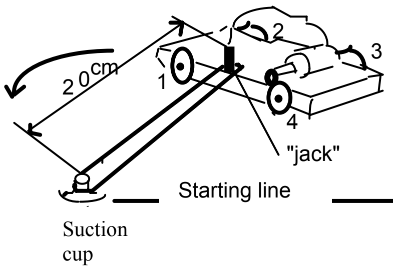
I1 Average frequency of rotation

1.1 Preliminary note:



Fixing the suction pad requires a perfectly smooth surface over a few square centimetres. If such a surface is not available, a thin 10 x 10 cm plastic plate attached by adhesive tape on a table may be used as shown in the diagram hereof. The suction pad will be placed at the centre.

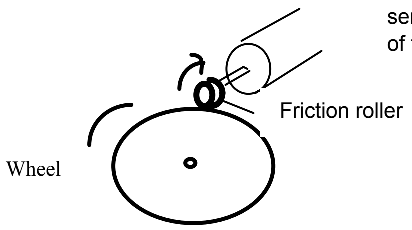
1.2 Set-up and experiment



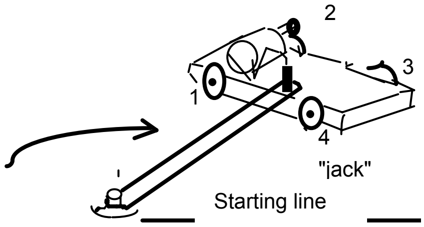
2.1 A 20 cm long loop of a thin cord passes on the groove of the suction cup and the “Jack” socket of the motor. The vehicle is thus connected to the central pivot that is made up by the suction cup.

2.2 The propulsion will be applied on the rear set of wheels by friction between the rubber roller and the wheel fitted with a tyre. Reproduce the roller and the wheel and mark the direction of rotation on the wheel.

2.3 Four batteries of voltage Up = 1.5 V are connected in series in the connector. What is the voltage at the terminals of the connector?



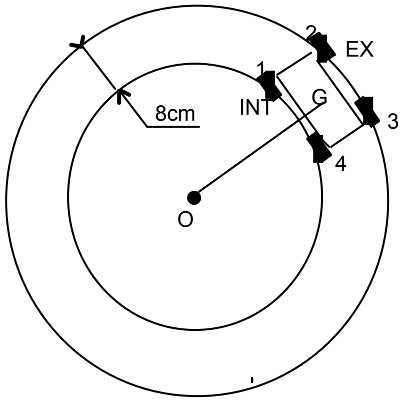
2.4 There exists an optimal setting to obtain the most efficient propulsion. Must the friction be applied on an inner (4) or outer (3) wheel? (CAUTION, we reverse the direction of propulsion). Or else (1) or (2)? Must one or two rubber tyres be placed on the rear set of motor wheels? Indicate without justifying your choice (The drawing above does not necessarily indicate the best assembly).



2.5 Position the vehicle on the starting line. Make N = 10 revolutions and measure the time D

2.6 Calculate the average frequency with a precision of two decimal digits.

I2 Average velocity



2.1 Measure the distance OG. O is the centre of the suction cup and G the centre of the printed circuit plate.

2.2 What distance L has G traversed when the vehicle has made one revolution?

2.3. What length L has G traversed when the vehicle has made ten revolutions?

2.4 Calculate the average velocity of the centre of gravity of the vehicle G.

2.5 Does the hub of the outer wheel have a velocity that is greater, lesser or equal to that of G? Justify.

2.6 Does the hub of the inner wheel have a velocity that is greater, lesser or equal to that of G? Justify

I3) Adhesion

Copy and complete the sentence below with the appropriate words.

"remove, , straight line, inferior, internal, add, external, greater, rotation, slide, circular"

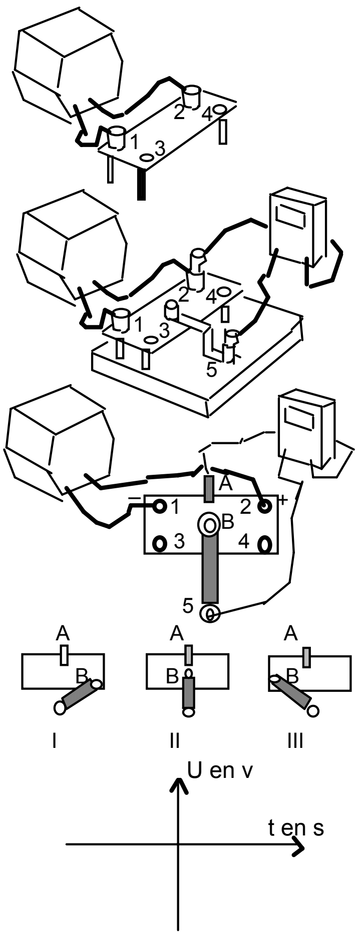
When the vehicle moves on a road.......... the outer wheel covers a distance that is ....to the inner wheel. Thus, it must make more rotations than the inner wheels. As the wheels are solidly fixed to the same axis, they are forced to make the same number of ...... This situation forces the inner wheel to .... In this case, sliding would be favourable and for this .... the rubber tyre of the wheel ....

16 Electric motor

Objectives:

To create front and rear propulsion of the vehicle using an electrical device
To study the rotation of the electric motor on a test bench (Variation in the number of revolutions N)
To install a mechanical reduction gear
To draw the graph N= f (U) (variation in the number of revolutions in relation to the voltage).

I1) Electrical device (change from DC voltage to variable AC voltage)



1.1 Resistor strip 10
Set the voltage to 6V DC. Connect the terminals 1 and 2 of the copper-clad strip to the generator. What is the voltage between the points 1 and 2 of the strip?

1.2 Install the copper-clad strip on the bracket. Position the movable cursor 5 as close as possible to 4 (start), then in the middle, and finally as close as possible to 3 (end).

Measure the voltages

Ustart Umiddle Uend

1.3 Voltage between the middle point and the cursor.
A crocodile clip A is placed in the middle of the strip between 1 and 2.
Assemble the following circuit. Place the movable cursor B as in the three previous cases.
Measure the voltages (indicate the values and the signs).

UI UII UIII

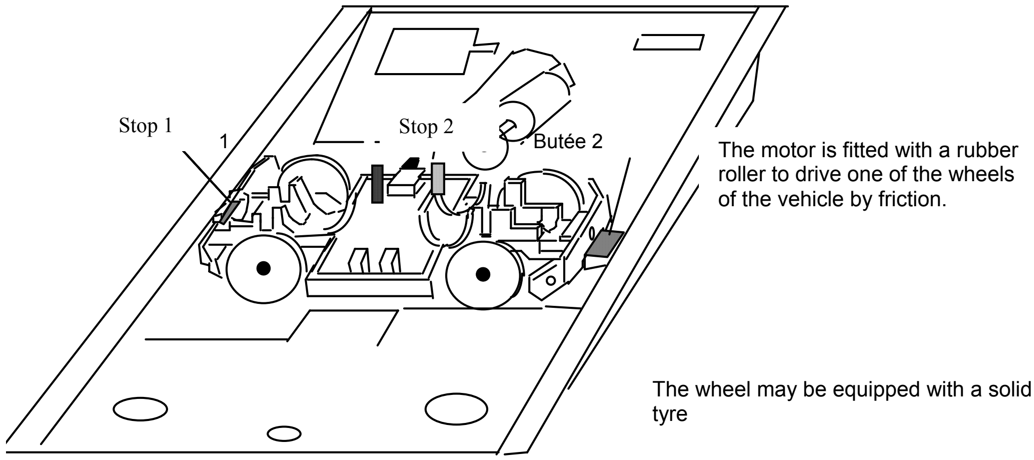
Indicate the sign of the terminals A and B in the three cases.
What conclusion do you draw on the nature of the voltage?

1.4 If we steadily move B from right to left and inversely in about two seconds, represent the graph of the voltage.

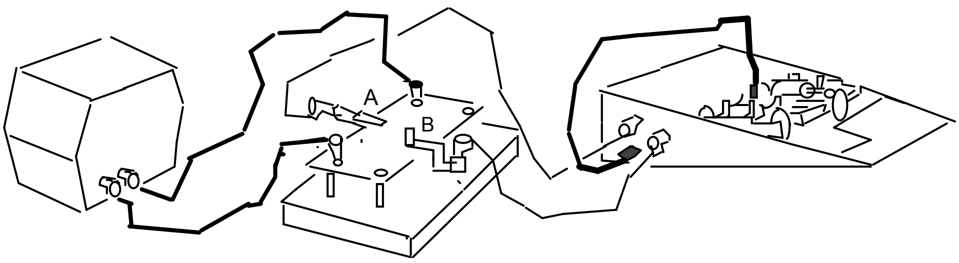
I2) Study of the forward and reverse travel on the bench

An electric motor has a direction of rotation that depends on the polarity of the current passing through it.
If the polarity is reversed, the motor rotates in the opposite direction.
Thus, changing the polarity must be possible at the motor's terminals.
The previous device helps attain this objective by moving the cursor from one end to the other from the centre point A.

2.1 The test bench consists of one of the half-cases
Place the vehicle as indicated in the drawing below (I). The vehicle rests on the bumpers on two grey bump stops of the box.
The wheels must be able to rotate freely.



2.2 Make the electrical connections as shown in the diagram below.



The power supply is set to 6V.

Check that the drive wheels reverse their direction of rotation when the cursor B is moved.

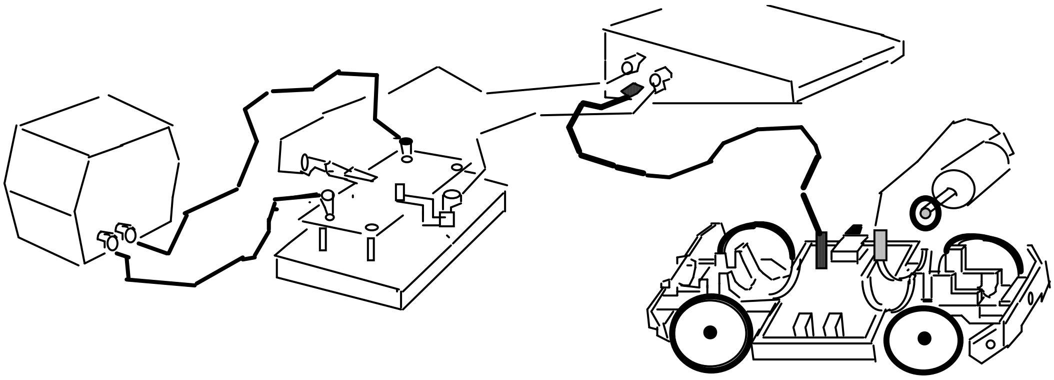
Does the motor rotate for all positions of the movable cursor B on the strip?

The power supply is set to 12V.

What difference do you observe in relation to the previous case?

I3 Forward and reverse propulsion tests on the table.

Remove the vehicle from the bench and place it at the centre of your table.
Some precautions need to be taken so as not to be surprised by the controls of the cursor.
Ensure that no wire hinders the movement of the vehicle. If required, a student may hold the power cord that connects the box to the vehicle in the air
In the first case, power with a voltage of 6V.
Initially, the cursor B will always be facing A.
Then slowly, it can be moved to the right or the left
What do you observe?



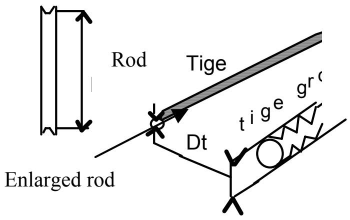
Set the power supply to 12V. Move the cursor as previously.
Describe the movement when you move the cursor from right to left and from left to right.

I4) Rotational movement-reduction or multiplication system of rotation

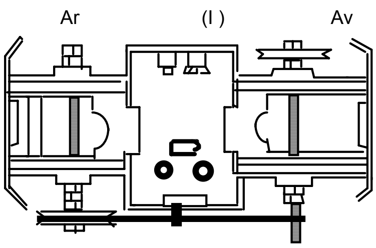
4.1 First system S1 (wheel threaded rod)

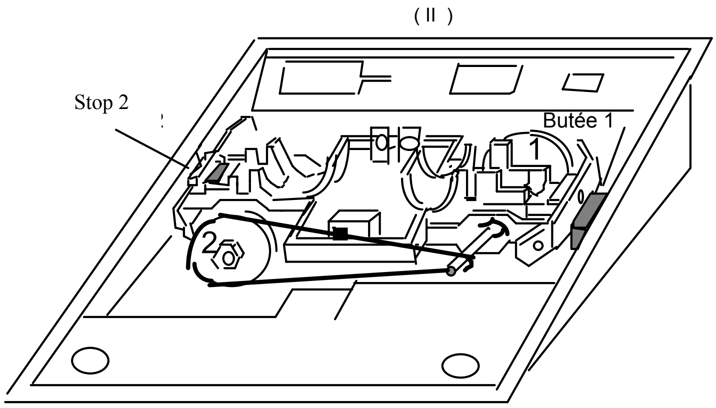
1.1 Measure approximately the inner diameter of the wheel without tyre Di. Measure the diameter of the threaded rod Dt.

1.2 Calculate the ratio Dr/Dt?



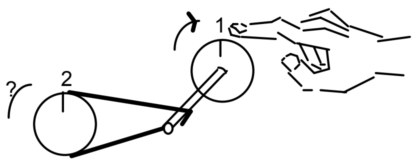
Dt





1.3 One student installs the front set of wheels when another installs the rear set. Assemble the two parts as in (I) then place the large rubber band in the groove of wheel 2 and on the threaded rod. Position the vehicle on the stops (II).

en (I)
. (II)



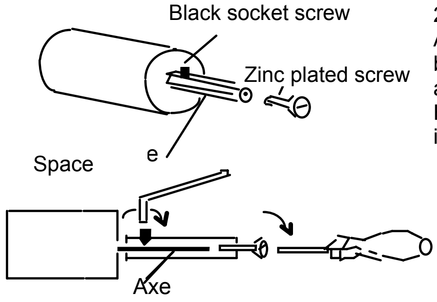
1.4 Draw with a pencil two vertical marks on the wheels 1 and 2. Drive wheel 1 with your finger as on the drawing. What is the direction of rotation of wheel 2?

1.6 How many revolutions must wheel 1 (n1) make so that wheel 2 makes one revolution (n2 = 1 rev)?

1.7 Calculate the ratio n1/n2 to one decimal digit. The system is said to be a reducing system. What do you observe comparing with the result of 2.1? Express this observation in a sentence.

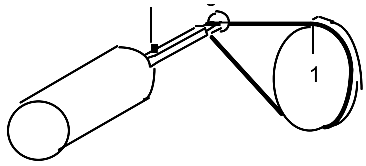
1.5 Rotate wheel 2 with your finger, does wheel 1 rotate more or less than wheel 2? The system is said to be a multiplying system.
How much is the ratio n2/n1?

4.2 Second system S2 (Wheel D1= 40mm, Screw D3= 3mm).

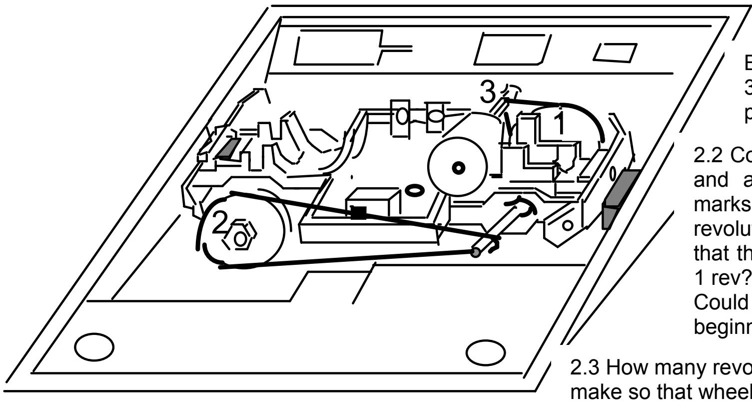


2.1. Installation

A) Install the spacer on the motor shaft as shown. Tighten the black screw with the woollen wrench to ensure the link between the axle and spacer.
Engage the zinc-plated screw at the other end and rotate till it comes in contact with the axle.



(II)



B) Couple wheel 1 and screw 3 with a suitable rubber band and place the vehicle on the stops.

2.2 Consider the black screw on the spacer and a mark on the wheel as reference marks (see drawing above). How many revolutions n3 must the motor axle make so that the wheel 1 makes one revolution: n = 1 rev?
Could this have been known since the very beginning?

2.3 How many revolutions n'3 must the motor axle make so that wheel 2 makes one revolution
n2 = 1 rev?

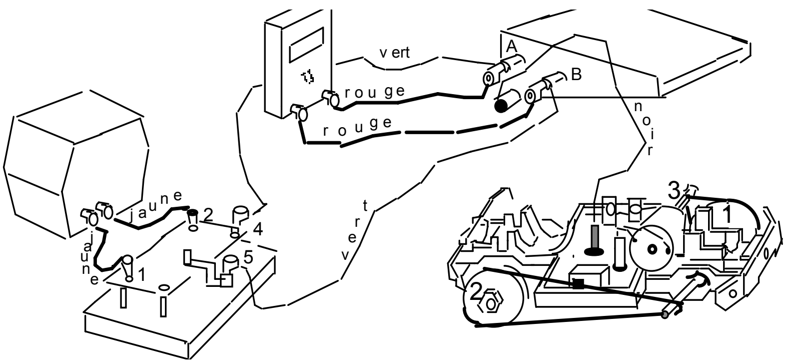
I5) Electric motor
(Graphical study of the number of revolutions/min in relation to the voltage at its terminals)

5.1 The axle of the electric motor rotates too fast for evaluating the number of revolutions per minute.

5.2 We will use the rotation reduction system studied earlier to measure a fixed number of revolutions of wheel 2. Then through calculations we will get the number of revolutions per minute of the motor.

5.3 We arbitrarily estimate that wheel 2 makes six revolutions: n2= 6rot. For a given voltage, we measure the corresponding time (t) required.

5.4 Electrical installation
We will respect the colour of the connections.
The voltage divider is powered between 1 and 2 by a DC voltage of 6V. A variable voltage is applied between outlets 4 and 5 on the terminals A and B of the half-case. The jack cord ensures the connection with the motor.



Once the electrical connection is made, place the vehicle on the stops.
Note: if screw 3 comes off from its housing, reverse the direction of rotation of the motor

5.5 First table

Voltage at the terminals of the motor in V	1.5	2	3	4	5	7	9
Number of turns set n							
Corresponding time t in s							

5.6 Second table.

Calculating the number of revolutions of the motor per minute
There is proportionality between the time and the number of revolutions made by the wheel 2.

If we name n' the number of revolutions after 1 minute, we have the relation:

$$\frac{n\ (tr)}{t(s)} = \frac{n'(tr)}{1min} \longrightarrow n' = \frac{n\ (tr)}{t(s)} \times 1min$$

$$n' = \frac{n\ (tr)}{t(s)} \times 60\ s$$

If we fix n = 6 rev, we get:

$$n' = \frac{6tr \times 60}{t} = \frac{360\ tr}{t}$$

The system has reduced the velocity of the motor by a factor of two. S1 (SCREW: WHEEL1) AND S2 (THREADED ROD, WHEEL2). To obtain the number of revolutions of the motor, the rotation of wheel 2 will have to be multiplied by a coefficient C.

$$C = \frac{40}{3} \times \frac{40}{5} = 106{,}6$$

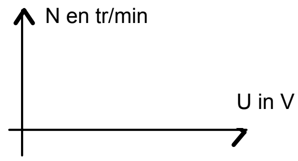
Let n by the number of revolutions of the motor in 1 minute N =n'X106.6

Voltage at the terminals of the motor U in V							
Number of revolutions of the wheel 2 in 1 minute							
Number of revolutions of the motor in 1 minute							

5.7 Draw and study the graph

7.1 Draw the x-axis and the y-axis. Indicate the magnitudes and units

Scales 1 cm …………………….. 1 V
2cm…………………………… 1000 rev.



7.2 Plot the points in the form of a cross

7.3 Calculate N2/U2, N4/U4, N6/U6. What can be said of these ratios?

7.4 Is there a proportionality between the number of revolutions and the voltage applied at the terminals of the motor? According to this graph, could this result have been anticipated?

ANSWERS TO THE FILL-IN-THE BLANKS EXERCISES

Page 3-4-5

I1 Freewheel

1.3 a: rim, b: hub. Threaded rod: shaft, axle.
1.5 J_1 = 3 mm, J_2 = 0 mm

I2 Fixed wheel

2.1 $J_1 = J_2$ = 0 mm
2.2 It is very difficult to answer because it is not easy to observe. If the ball bearing touches the rim and the hub, then it turns. If there is any play, however, it may be induced to slide. Actually both phenomena can occur; however, most of the time it turns. A video recording of the phenomenon run in slow motion would allow one to analyze the situation.
2.5 With the same thrust, the durations would not be equal. The action of the weight will make the ball bearing work under different conditions and therefore different frictions. On the other hand, if one were in space the durations would be equal for equal thrusts.

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I1) Types of displacements

1.2 "the wheel train (1) turns while the wheel train (2) slides. The adherence is insufficient in this second case. One can conclude that if one presses the same way in (1) and in (2), the adherence is greater in (1) than in (2). It thus depends on the materials in contact."

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I1) Motion

1.2 "When a south pole is facing another south pole, the magnets then repell each other." "When a north pole is facing a south pole, the magnets then attract each other."
1.4 "The force is oriented from right to left, whereas the chassis moves from left to right."

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I1) B) Drive wheel/ground start

4.1) "When the front drive wheels contact the sheet, they exert a double action. On the one hand, they exert vertical pressure on the sheet; on the other hand, they act tangentially. This second action causes the sheet to slide from right to left on the table. The passive, rear wheels then interact with the sheet at the same time as the front wheels. The sheet then remains stationary under the effect of the table and the two wheel trains."

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4.3) Experiment: 3.2 "When the front wheel drive train brakes on the sheet, it exerts a double action. It exerts vertical pressure on the sheet and pushes it horizontally. In this case, the displacements of the vehicle and the sheet are in the same direction."
4.4) Summary: "according to the law of reciprocal actions, if the wheel pulls the sheet from right to left, the sheet then pulls the wheel from left to right."

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I1) Sliding, skidding

1.3 second experiment

3.1 "the car starts to move under the effect of its weight, there is a dynamic effect, it slides sideways, in other words it skids."

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I3) Adherence

"When a car turns or travels in a circular path, the outer wheel travels a greater distance than the inner wheel. It must therefore complete more turns than the inner wheel. When the wheels are rigidly linked on the same axle, they are forced to make the same number of turns. This situation causes the inner wheel to slide. It would therefore be in one's interest to enhance this sliding and to do so the rubber tire is removed from the inner wheel."

Note the improved efficiency that is obtained with a tire on the outer drive wheel only. (1 tire on the outer drive wheel and three wheels without tires, with rear drive).

NOTES

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