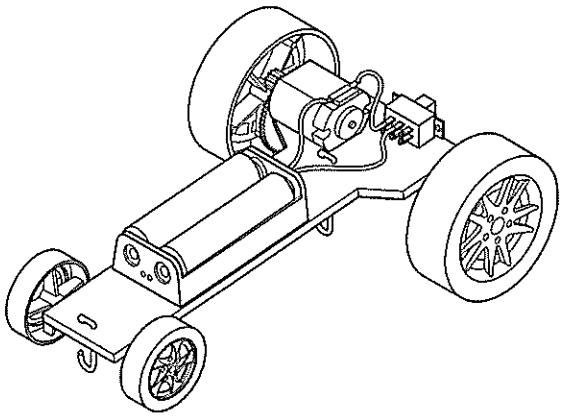
DRAGSTER – NO SOLDER

CONTENTS:

DESCRIPTION

The DRAGSTER is a simple motorised vehicle, for students to design and construct. It is powered by a small electric motor, and students are able to select the vehicle's gearing, dependent upon the speed and acceleration required.

The vehicle has been designed to provide an easy introduction to electro-mechanical devices. It is also intended that a number of DRAGSTERs can be used to compete in a class environment. This puts the additional requirement on students to look into the effects of gearing on speed and acceleration, and to consider these factors in their vehicle design.



SECTION 1: GENERAL AND PLANNING INFORMATION

1. DESIGN CONSIDERATIONS

1.1 THE PROJECT

The major aspects of this project are the planning, design, construction, assembly and evaluation stages of the vehicle. To this can be added usage and performance (including the races).

1.2 DESIGN BRIEF

Each student will construct a vehicle to compete in a race against the other students in the class. Each student receives the same components and is to use these components to design and construct their vehicle. The vehicle is designed to travel along a fishing line 10mm above the surface the DRAGSTER will race along.

1.3 GENERAL

The design stage is crucial. This allows the desired size and shape of the vehicle's platform to be developed on paper. This layout affects the functionality and the ease of assembly. The design of the vehicle should be drawn full size (showing component layout and locations) in the students' log book. The drawing should be a plan view (viewed from above) showing all of the important measurements.

The following points are given as a list of things to be taken into consideration for planning:

- The DRAGSTER consists of a platform on which the various components are mounted.
  Note: For best functionality of the vehicle, the designer must look at the vehicle as a complete unit, and not just as separate parts.
- The speed of the motor, under load, is approximately 6500 RPM.
- Of the Spur and Pinion gears provided, only one of each type is needed. The gears provided allow for a large choice of ratios, and the student needs to select the desired gear ratio. The acceleration and speed this vehicle will be capable of are decided by this selection.
- Note: the higher the gear ratio, the faster the acceleration but the lower the vehicle's top speed.
- The guide line (fishing line) should be at a height of 10mm above the surface the vehicles will race along.

1.4 DESIGN SPECIFICS

Define the shape of the DRAGSTER's platform - this affects the weight of the platform. Before starting construction, the location of all components needs to be carefully planned and laid out.

- When designing the platform, the dimensions of the supplied components (such as the axle, gears and tube, battery compartment, electric motor and switch) must be considered.
- The size and shape of the vehicle platform is up to each designer. We suggest that the material for the platform should be 4mm thick plywood, and not larger than 150mm x 60mm (although the axle allows a wider platform).
- The switch should be mounted on the rear end of the platform.
- Weight distribution and ease of operation should be taken into account.
- The plastic tube (supplied) is for use as an axle guide, and is attached (glued) to the platform. This axle guide tube length can be a limiting factor to the width of the vehicle. The tubes should be about 2-3 mm longer than the width of the platform to which it is glued. This will prevent the wheels rubbing against the base, and slowing the vehicle down.
- The steel rod must go into the wheel hole all the way. Hint: Place a nail or piece of wire into the wheel hole to measure its depth. The length of the steel rod needed is worked out by taking the length of the plastic tube plus 2 times the depth of the wheel hole (ie. for both wheels) plus 2 mm for clearance (so the wheel will not jam up against the plastic tubing).
- When working out the rear axle length, remember to allow for the large (spur) gear as well.
- Measurements showing where the axles will be placed are also needed, so that the rear axle large (spur) gears will also mesh with the motor's pinion (small) gear.
- Allow for 4 small holes in the platform – these are required for the two guide hooks (2 holes at the front, and 2 at the rear - these holes should be 2mm either side of the centre line. These must be in an area of the base not covered by the battery holder or motor.

Once this has been completed, construction work can begin.

SECTION 2: COMPONENTS & MATERIAL REQUIRED

2.1 COMPONENTS SUPPLIED

The following components are supplied in the kit:

1 x Battery holder – 2AA (BH2AA)
3 x Connector – Twist on (CONN-SC)
2 x Copper wire – 1mm x 100mm
1 x Electric motor 1.5-4.5V with wires (MOT12W)
1 x Pinion gear 10T – 1.9mm hole
1 x Pinion gear 12T – 1.9mm hole
1 x Pinion gear 8T – 1.9mm hole
2 x Shaft – Steel – 2.5x120mm
1 x Spur gear 50T/10T – white 2.4mm hole
1 x Spur gear 60T/10T – white 2.4mm hole
1 x Switch – Sliding on-off with wires (KSSWS-W)
2 x Tube – Guide – 100mm long White
2 x Wheel – 30mm dia – 2.4mm hole (W30C)
2 x Wheel – 52mm dia – 2.4mm hole (W52C)

2.2 ADDITIONAL REQUIREMENTS

The following items are available from Scorpio Technology and need to be ordered separately:

- Battery – AA, 2 required (BATTAA)
- Drill Bit – 2.3mm (DB2.3)
- Self-adhesive tape – Single-sided
- Self-adhesive tape – Double-sided
- Corflute 200mm x 100mm
- Fishing line (for racing)

NOTE: If a number of students are going to construct the DRAGSTER (i.e. as a class project), it is recommended that the class purchase a tube each of steel rod and plastic tube and some extras of all the remaining components (especially gears). This is to enable the replacement of any damaged or lost parts that (inevitably) occur during student work.

The following material is to be supplied by the student / designer:

- Material for the platform (PVC or acrylic sheet, Plywood, Corflute, etc.)
- Electric hook-up wire – Multi-strand

2.3 TOOLS REQUIRED

The following tools are required:

- Assorted hand tools (eg. Craft knife, 200mm Bolt cutters, drill)

SECTION 3: FABRICATION AND ASSEMBLY

3.1 CONSTRUCTION OF THE PLATFORM

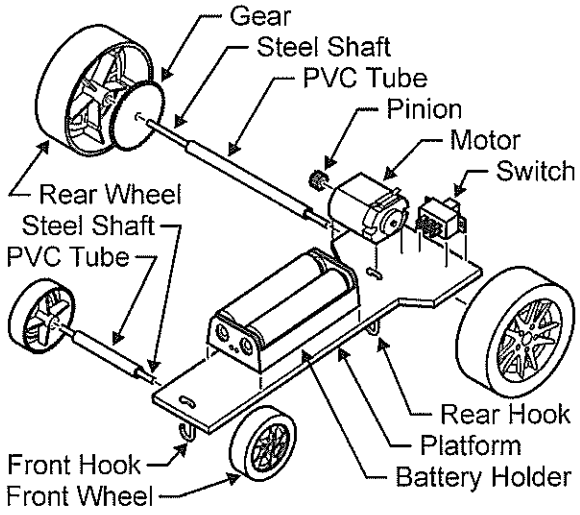
- Use the drawing produced to mark out the platform and cut it to shape.
- Draw a centre line down the middle of the platform. Mark the positions of the 4 small holes for the two guide hooks. Drill the four 2.3mm diameter holes.
- Sand the cut edges so they are smooth – the base is now ready for mounting the components.

3.1 ASSEMBLING THE COMPONENTS ONTO THE PLATFORM

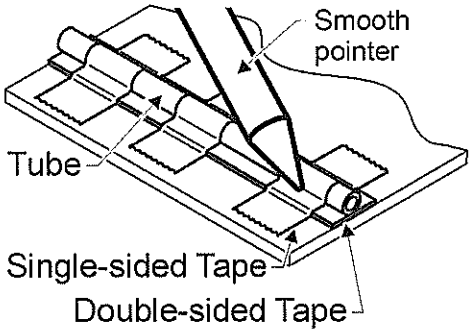
3.1.1. MAKING AND ATTACHING BOTH THE AXLE GUIDE TUBES

- Cut the plastic tubes to the lengths required. Make sure that the ends of the tubes are smooth (file or sand them) to further reduce friction.
- Glue the plastic tubes in place on the platform. Make sure that the tube is straight and not on an angle (or the DRAGSTER will steer to one side).

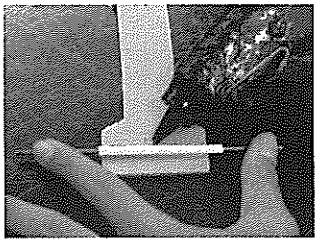
NOTE: you can attach the plastic tubes on to the chassis using double sided foam tape or hot glue.



OPTIONAL ATTACHMENT METHODS



ATTACHING THE AXLE TUBE TO THE PLATFORM USING SINGLE AND DOUBLE SIDED TAPE.



ATTACHING THE AXLE TUBE TO THE PLATFORM USING HOT GLUE.

WARNING: If using hot glue, be very careful, as it can burn you, if you get it on yourself.

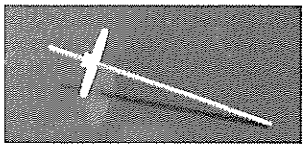
WARNING: hot glue can heat up the plastic tube and cause it to bend, making the axle a tight fit. To prevent this, and keep the plastic tube straight, place the axle through the plastic tube before gluing and hold the axle down (as shown in the picture) until the glue sets.

3.1.2. MAKING THE FRONT AXLE (using 30mm wheels):

- Measure and cut the steel rod to length and de-burr the ends.
- Insert the steel axle into one of the (30mm) front wheels. Using a hammer, carefully tap the steel axle down into the wheel hole.
- Slide the axle into the plastic tubing, place the second wheel on the end of the steel axle and carefully tap the wheel down onto the steel axle.

NOTE: Ensure that the inside of the wheels have clearance on each side, and are able to turn freely.

3.1.3. MAKING THE REAR AXLE ASSEMBLY (using 52mm wheels):

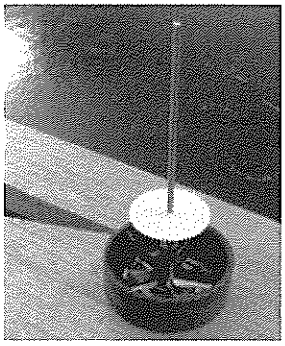


THE SPUR GEAR MOUNTED ON THE AXLE

Install the Spur gear to the axle:

- Take the chosen spur gear (either 50 Tooth or 60 Tooth), and place it with the pinion (small) gear facing downward onto a firm surface.
- Insert the steel axle into the hole and carefully tap the steel axle all the way down into the gear - the steel axle must protrude through the gear by 5-10 mm. Hint: This can be achieved by drilling a 7mm hole in a piece of scrap wood and using this to support the gear when you tap the steel axle through the gear.

3.1.4. INSTALLING THE AXLE TO THE WHEEL:

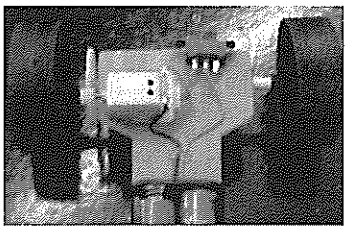


THE AXLE & GEAR INSTALLED IN THE REAR WHEEL

- Take the axle and place one end into the hole in the wheel.
- Using a hammer tap the axle down into the wheel hole until the gear is flush with the wheel and the axle is at the end of the hole. (See picture)
- Slide the axle into the plastic tubing.
- Place the second wheel onto the end of the axle and carefully tap the wheel down onto the axle, until the end of the axle is level with the end of the hole.

Notes:

- Ensure that the inside of the wheels have about 1 mm clearance between them and the plastic tubing to allow them to turn freely.
- If there is too large a gap, the axle can slide back and forth and prevent the motor's pinion gear from meshing properly with the large gear.



THE AXLE AND GEARS IN PLACE

- Take the selected pinion gear and place it on a firm surface. Place the electric motor's shaft into the hole and tap the opposite end of the shaft (seen slightly protruding from the rear end of the motor) with a hammer until the motor shaft is at the end of the pinion gear hole.

HINT: Place the gear on the bench, insert the motor shaft into the pulley's hole and gently tap the end of the shaft (where it exits the motor) with a small hammer.

WARNING: Don't just push the motor down as this can push the motor armature out of its bearings and jam the motor.

SECTION 4: ELECTRICAL ASSEMBLY

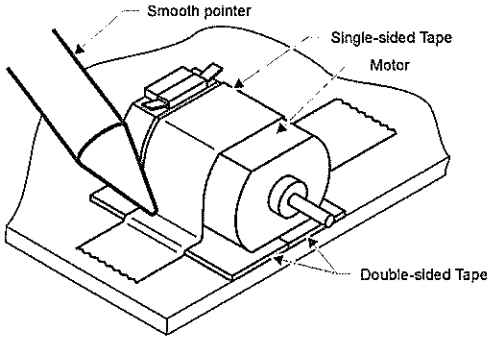
4.1 ELECTRICAL COMPONENTS

4.1.1. MOUNTING THE MOTOR IN PLACE

- Place the DRAGSTER on a flat surface. Place the motor (with the connecting terminals facing up) on the platform so that the teeth of both gears engage properly. Mark around the motor.

- Apply some hot glue or double sided tape inside the area that you marked - place the motor in position so that both gears engage properly (make sure that the motor is mounted square to the large gear, or the teeth will not engage properly).

NOTE: If using hot glue, roughen the surfaces to be glued with sandpaper to improve adhesion). Hold the motor in place until the glue sets.



WARNING: If using hot glue, be very careful, as it can burn you, if you get it on yourself.

4.1.2. MOUNTING THE SWITCH

- Glue the slide switch in position at the rear of the vehicle's platform.

WARNING: Take care not to get any glue into the ends of the switch, as this will prevent it from operating.

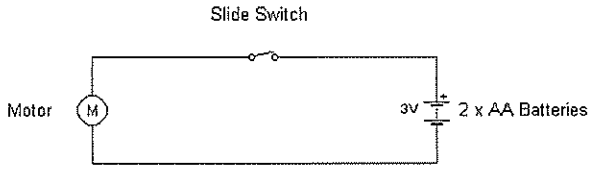
4.1.3. ATTACHING THE BATTERY COMPARTMENT

Glue the battery compartment onto the platform (the battery compartment's surface may need to be roughened with sandpaper to get the glue to stick to it).

4.2 WIRING THE ELECTRICS

The Switch should be wired as shown in the "Circuit diagram

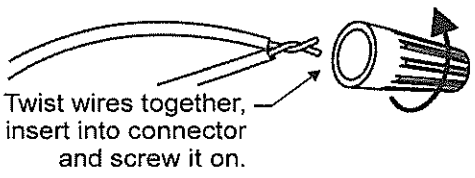
- Connect the battery holder's red wire to one of the red wires from the switch. Twist them firmly together.
- Connect the switch's other red wire, to the motor's red wire. Twist them firmly together.
- Twist the black wires from the motor and battery holder together.



CIRCUIT DIAGRAM

4.3 TESTING

- Insert the batteries, and turn the switch on:
  - if the vehicle moves forward (ie. to drive DRAGSTER forward), your wiring is correct.
  - If the vehicle goes in reverse, you will need to swap the motor's wires.

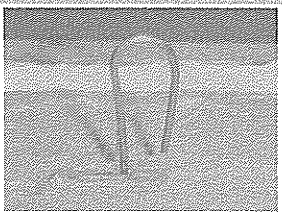


Note: Remove the motor's red wire from the switch and untwist the black wires from the motor and battery holder. Twist the red wire from the motor to the black wire from the battery holder .Connect the motor's black wire to the remaining red wire on the switch. Twist them firmly together.

- Twist the ends together and finish by screwing on the screw-on connectors.
- Test the operation of the vehicle to confirm everything is operating correctly. When you are satisfied that it is, use a couple of small dobs of glue to fix the wire to the base.

NOTE: This kit has components that allow this to be assembled without soldering. However, the connections will be more effective and permanent if they are soldered.

4.3 HOOK (FOR THE GUIDE LINE)



- The last task is to make the (copper) wire hooks that will guide the DRAGSTER along the guide line. As the rear of the vehicle sits higher than the front of the vehicle, the hook at the back must be longer.
- Bend the copper wire from the kit into the shape shown. Push it up through the two holes (already drilled). Bend the short section over to hold the wire in place. Use some glue to hold the wire firmly in place. Cut off the excess.
- Bend the remaining wire into a hook shape and construct the second hook. NOTE: The bottom of the hooks should be about 5 mm above the ground (the line is 10mm above the surface). The hook should be long enough to prevent the guide line from coming out of the hook when racing.

SECTION 5: INVESTIGATION

The following section can be used as a basis for ideas on related topics that would enhance student learning. These can be used in the classroom both as group projects and individual topics to produce a large body of information for student instruction.

The following are some ideas worth considering.

5.1 MATHEMATICS

Students are to work out speed in Km/h (using the distance travelled and the time taken for the vehicle)

Find:

- Average speed, Final Speed (Top speed), Final drive ratio
- Work out RPM of wheels from data on motor and gears used.
- Find out how many time the wheels turn over the race (front and back)
- Weigh all the vehicles and draw a graph in relation to their performance.
- Draw a chart or table showing the gear ratios of each vehicle, to show how this relates to performance.

5.2 ELECTRICAL

- What are: Voltage, Current, Resistance?
- Describe the type of circuit used to control the DRAGSTER (series, parallel).
- What is Ohms law?
- Measure the motor 's voltage and current - work out the motors resistance.
- Find the formula used to work out power in an electric circuit. Work out the power generated by the motor.
- How does a battery produce electricity?
- What electrical symbols are used to represent the motor, switch and batteries?

5.3 DESIGN

- Work out the factors that affect how fast the DRAGSTER will travel.
- Write up a Design Brief for the construction of the vehicle.
- Draw up a design of your vehicle, using a top view and side view. Include all necessary measurements.

5.4 INVESTIGATE

- Explain what friction is.
- Explain how the following surfaces would effect the operation of your vehicle, and give examples of each - High friction, Medium Friction, Low friction
- Investigate the best surface within the school to run the race. Why is this so?
- Produce a (Powerpoint) presentation that demonstrates how an electric motor works.
- What is a (gear) system?
- Explain the DRAGSTER's: Input, Control, Process, Output
- Investigate how gears work and explain Gear ratios.
- Explain the motion of gears in a gear train.
- Give examples of different types of gear systems and where they are used.
- Present a demonstration about gears and gear ratios
- Set up a chart of the different gear ratios available using the various gear combinations. Record varying acceleration rates and top speeds for each combination. What do the graphs of these look like?

5.5 ENVIRONMENT

- Investigate the advantages and disadvantages of electric vehicles.
- Investigate the current developments in the production of electric vehicles around the world.

5.6 EVALUATE

All students will complete an evaluation on their DRAGSTER. Devise a series of questions to see if your design meets the requirements of the design brief. For example:

- How well does your design function.
- How good was its performance? Did it achieve the anticipated results?
- Does your design look good?
- Can you improve your design?
- What are the best features of your design?
- Use De Bono's hats to formulate a question for each hat.

5.7 STUDENT LEARNING

Have students complete a mind map using Inspiration or drawing by hand about their DRAGSTER before beginning construction work. Give them some starting points.

E.g. Electricity, batteries, electric motor, gears, wheels, voltage current, resistance, power, friction, weight, wheels etc.

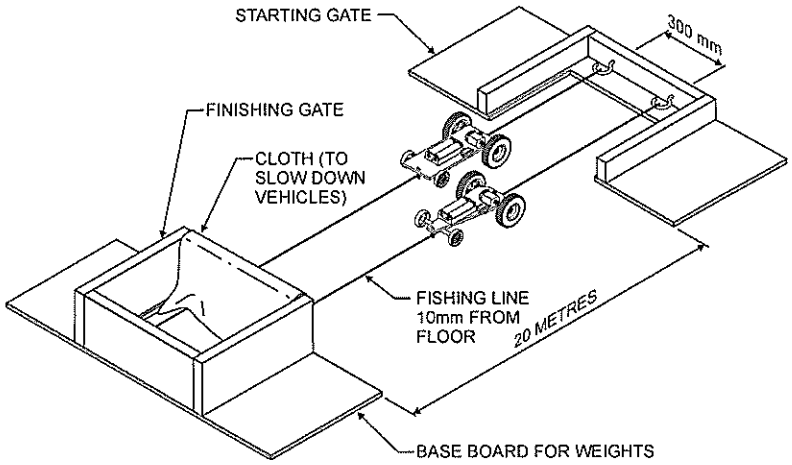
Complete a second mind map after construction is complete. Compare the structure and composition of both maps.

SECTION 6: SUGGESTED RACING RULES

6.1 RACE RULES

- The race is over a 20 metre distance.
- Each DRAGSTER is guided along a (fishing) line 10mm above the racing surface.
- The guide line must be tight.
- Vehicles must be built using the components in the DRAGSTER kit sold by us (Scorpio Technology).
- Vehicles may only use 2 x AA batteries.

DRAGSTER RACE GATES



- Competitors have a maximum of 1 minute to attach their vehicle to the guide line and be ready to start.
- The vehicle is only to be turned on when the starting signal is given.
- No pushing the vehicle at the start is allowed.
- Vehicles that do not start or stop during the race are disqualified.
- If a vehicle leaves the guide line it is disqualified.
- A separate stopwatch will be used for each DRAGSTER competing

SECTION 7: THEORY

7.1 SPEED AND ACCELERATION

7.1.1. AVERAGE SPEED

Did you know that you can calculate your vehicles average speed during its race?

You need to know the distance over which your vehicle will race. Time the duration it takes from start to finish with a stopwatch. You can use the following method to calculate how many Kilometres per hour (km/h) your vehicle averages. For example if your vehicle is racing over 20 metres and it takes 5 seconds to cover the distance:

- Divide 1000 metres (the length of one kilometer) by the length of your racetrack (in this example 20 metres). **1000/20 = 50**
- Multiply the time taken by your vehicle to complete the race (in this example 5 seconds), by the result from the previous calculation. **5 x 50 = 250 seconds**

This is the time it would take to travel one Kilometre

- Work out how many seconds there are in an hour. **60 x 60 =3600 seconds**
- To calculate the average speed in Kilometres per hour, divide the seconds in an hour (3600 seconds) by the time it takes to travel one kilometer (in this example 250 seconds). **3600/250 = 14.4 Kilometres per hour**
- This is the average speed obtained over the race. Remember your vehicle is not moving at all at the start. This means it must be going much faster (than the average speed) by the end of the race. How fast is your vehicle going at the end of the race? Hard to tell? No, not really thanks to something called physics!!!!

7.1.2. ACCELERATION

First you must find the acceleration of your vehicle. Acceleration is a measure of how fast your vehicle's speed is increasing. Acceleration is measured in metres per second

squared (m/s²). Another term that will also be used in the calculation is velocity. Velocity is a measurement of speed. Velocity is measured in metres per second (m/s).

- To find this, a formula is used and it assumes that the acceleration is constant (ie. the acceleration is the same throughout the race).

Distance travelled = the starting speed of the vehicle + ½ x acceleration x time taken ²

To find the acceleration for our example:

20 metres = 0 + ½ x acceleration x 5²

20 = ½ x acceleration x 25

20/25 = ½ acceleration

0.8 = ½ acceleration

0.8 x 2 = acceleration

Therefore **Acceleration = 1.6 metres per second squared (1.6m/s²)**

7.1.3. END VELOCITY

To find the velocity of the vehicle at the end of the race another formula is used.

Velocity = the starting speed of the vehicle + acceleration x time taken

Velocity = 0 + 1.6 x 5

Velocity = 8 metres per second (8 m/s)

To calculate the final speed, multiply the velocity by the number of seconds in an hour. **8 x 3600 = 28,800 metres or 28.8 Km per hour.**

Can you spot the relationship between the average speed and the maximum speed of a vehicle that starts from a stationary position? What is it, how can this be explained?

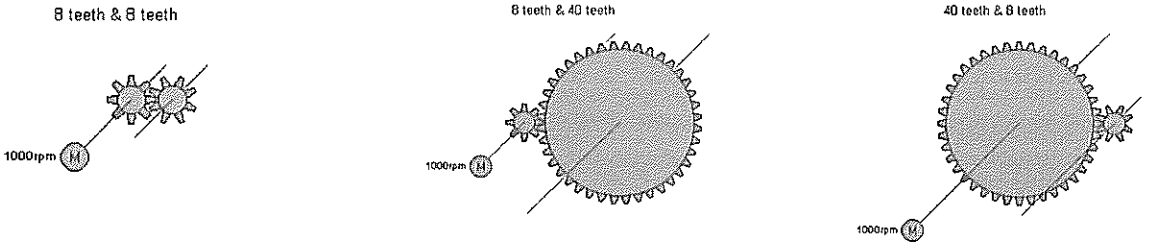
NOTE: The time and race distance used in this example are made up values, to show how these calculations work. Your vehicle may achieve better speeds than given in the example.

7.2 CROCODILE TECHNOLOGY

The following investigations are provided for teachers who have access to **Crocodile Technology** (a commercially available software product) to enable students to investigate gears ratios and the effect of vehicle weight.

7.2.1. GEARS

- Draw up the following gear arrangements using Crocodile technology.
- Select gears with the same number of teeth as shown and change the motor speeds to 1000 rpm



- The gear connected to the motor is called the driver gear. The other gear that moves when in contact with the driver gear is called the driven gear.
- Use the mouse (by placing it on the motor or gear) to measure the speed in rpm of the driven gears (ignore the degrees reading) and record the speed of each in the table below.

Motor RPM	DRIVER rpm	DRIVER (teeth)	DRIVEN (teeth)	DRIVEN rpm
1000		8	8	
1000		8	40	

1000		40	8	

- From your readings try and work out the speed of the driven gear, for the gears shown in the table below.

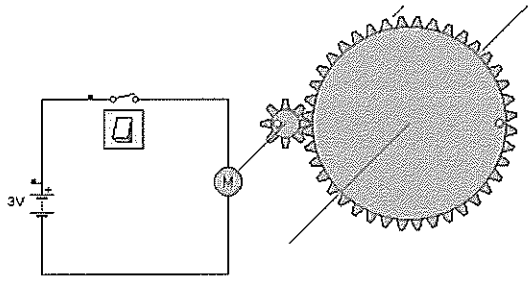
DRIVER rpm	DRIVER (teeth)	DRIVEN (teeth)	DRIVEN rpm
1000	16	16	
1000	8	24	
1000	16	8	

Explain how you did this for each problem.

- 16 to 16
- 8 to 24
- 16 to 8

7.2.2. CIRCUIT OF THE RACING VEHICLE

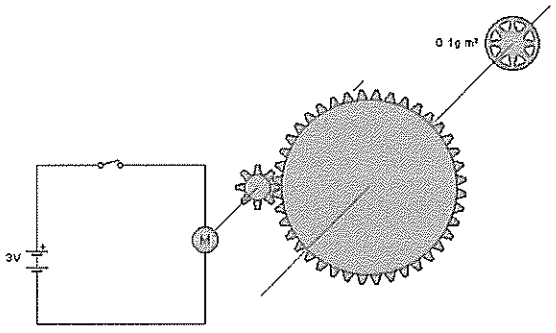
- The circuit used is a simple series circuit, which contains a battery, switch and motor and is shown at right.
- Draw up the circuit in Crocodile technology (8 to 40 teeth) and confirm its operation by turning on the switch. Measure the speed of the driven gear in rpm. Record the speed below.



- Draw up another circuit with the battery reversed so that positive (+) is at the bottom of the screen. Operate the switch and observe the difference in operation between the circuits. Record your observation below.

7.2.3. THE EFFECT OF WEIGHT ON THE OPERATION OF THE MOTOR

- Attach a flywheel to the large gear as shown. Set the inertia to 0.1 gm². This simulates the weight of your vehicle.
- Turn on the switch and measure the speed of the driven gear. Record the maximum speed and how long it takes to reach that speed. Record it in the following table. Turn off the switch and change the inertia to the values shown in the table and record the time it takes to reach maximum speed.



Flywheel Inertia	Max Speed	Time to reach max. speed
0.1 gm²		
0.2 gm²		
0.5 gm²		
1 gm²		

4 gm^2		

- From the times that you have recorded, what conclusion can you draw about the effect that extra weight will have on the speed that your vehicle will reach?