Grip it or Slip it?

This physics module is designed to be used with mixed ability groups aged 15 -17.

Abstract

The purpose of this series of activities is to allow pupils to join an investigative team which will examine the factors that cause a car tyre to slip on the road. Students will work in groups to discuss, design and carry out their own investigation into one factor that affects a tyre's ability to grip the road. This module is designed to be student focused with each group deciding what factor they would like to investigate and how they would like to do so. It is envisaged that the teacher's roll in the class will be that of a guide and mentor.

Sections include:

1. Student Activities
2. Teaching Guide and Notes
3. Assessment

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Objectives of Module: To give students an understanding of the factors that affect friction by conducting a series of investigations into each factor.

Learning Outcomes: On completion of this module students should be able to:

- Discuss the factors that affect friction
- Design a mind-map illustrating the factors
- Design and plan an investigation into one of the factors affecting friction
- Carry out an investigation
- Take and record measurements
- Reach a conclusion based on those measurements
- Report and discuss their finding

Curriculum Content: Forces, friction, application of friction, lubrication, use of datalogging sensors, IT and the analysis of quantitative data.

Prior Knowledge: concept of a force, the Newton is the unit of force. Pupils should also have investigated forces and the effect of lubrication.

Kind of Activity: Information processing, communicating, being personally effective, working with others, critical and creative thinking.

Anticipated Time: This module is designed to be taught over three 55 minute classes. Student task 1 and 2 are to be covered in the first class. Whilst tasks 3 and 4 will each requires a 55 minute class of their own.

This unique teaching-learning material is intended to guide the teacher towards promoting students' scientific literacy by recognising learning in 4 domains – intellectual development, the process and nature of science, personal development and social development.

Its uniqueness extends to an approach to science lessons which is designed to follow a 3 stage model. For this the approach is intentionally from society to science and attempts to specifically meet student learning needs.
This uniqueness is specifically exhibited by:

1. a motivational, society-related and issue-based title (supported in the student guide by a motivational, socio-scientific, real life scenario);
2. forming a bridge from the scenario to the scientific learning to be undertaken;
3. student-centred emphasis on scientific problem solving, encompassing the learning of a range of educational and scientific goals;
4. utilising the new science by including in socio-scientific decision making to relate the science acquired to societal needs for responsible citizenship

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Student Activities

Scenario

Have you ever been stuck standing on a bus with a crazy driver that drives way too fast? Each time he turns a corner everyone gets hurled from one side of the bus to the other; old ladies shopping bags spill all over the floor, mothers grab their kids as they go whizzing off the seat and you end up crushed against a smelly stranger who hasn't washed in days. All the time you are asking yourself, how do the tyres stay on the road?

In this series of activities you are invited to join an investigative team of scientists to examine what it is exactly that stops a tyre from slipping on the road.

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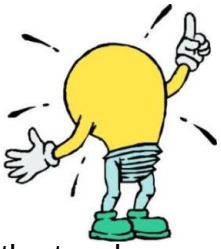
Your Tasks

Task 1: What causes a tyre to grip or slip on the road?
As a group you must meet and try to identify all the factors that contribute to a bus tyre gripping or slipping on a road. As part of this process your group must produce a mind map detailing what you believe to be the important factors.

Task 2: As a group you are asked chose one of the factors that you would like to investigate. You then design an experiment that will investigate whether or not that factor does affect a tyre's ability to grip the road. You are asked produce a sketch of the apparatus you intend to use with a list of the materials you will require to carry out the investigation. Once this has been completed the group needs to submit their plans to the teacher.



Task 3: Once your teacher has reviewed your plans and supplied you with the materials you can carry out your investigation. It is the duty of each student within the group to ensure that they record their own set of results. Upon completion of the investigation groups are asked to discuss their outcomes and reach a conclusion.

Task 4: Each group is asked to give a short presentation to their fellow classmates explaining what factor they choose to investigate, how they investigated that factor and what their findings were.

Task 5: Each student is invited to write up a laboratory report describing their investigation under the following headings:

- Abstract
- Introduction
- Apparatus
- Method
- Sources of error
- Conclusion

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Teacher Guide

Introduction

This module aims to be as open as possible to the students own lines of enquiry. However it is recognised that teaching such a lesson will pose the teacher with issues that they wouldn't normally meet when teaching material directly from the curriculum. This section offers suggestions to the teacher as to how they can provide more structure to the lesson. It also includes the actual factors that affect friction and gives a list of some suggestions that students may put forward. Also included is a list of possible methods which students could use to test their hypothesis.

Friction

There are a number of different types of friction but for this investigation it is only static friction that needs to be investigated. The following simplified laws describe how friction works between two surfaces:

1. Friction always opposes motion between two surfaces – friction will always try and slow things down.
2. Friction doesn't depend on the area of contact. This is a surprising law. If we look at the two identical objects show in figure 1 below they will both have exactly the same amount of friction when the same size force is applied to them even though in the first case the area of contact is much greater. The truth of this is evident when one considers a motor bike going around a corner. The actual area of contact between the tyre and road is tiny however it doesn't affect the tyres ability to grip the road.

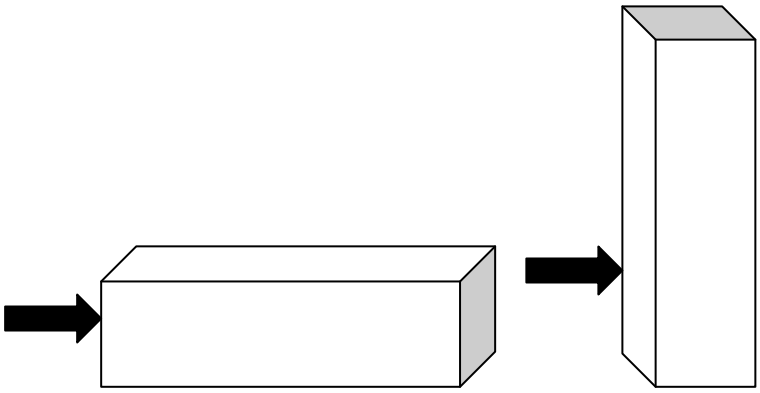

Figure 1

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3. Friction depends upon the normal reaction. The greater the weight of an object the greater the size of the normal reaction and hence friction. In figure 2 the second object has a greater weight and consequently there is a greater amount of friction.

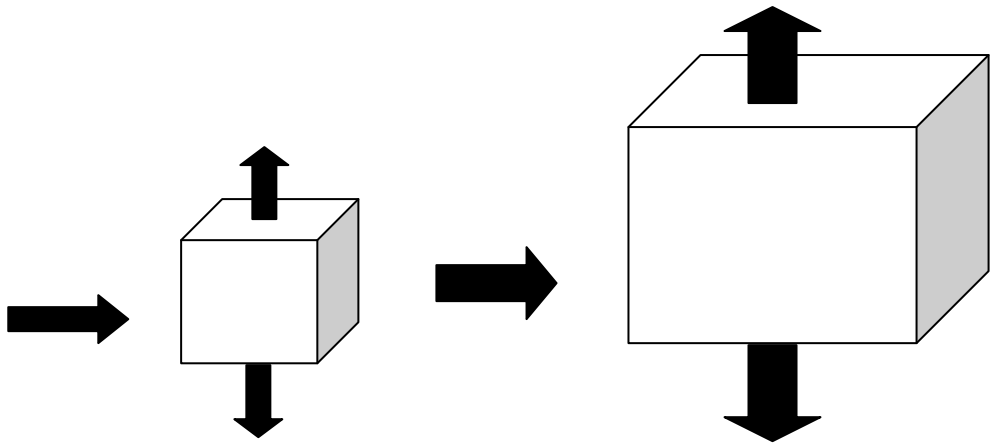

Figure 2

Note: When asked to consider a bus tyre slipping a lot of students will envisage a scenario where the bus driver slams on the breaks and the wheels lock allowing the tyres to slip forwards. However for the purpose of this investigation students are asked to focus only on the sideways slipping of the bus tyre on the road.

Student Suggestions

During task 1 students are asked to produce a mind-map listing the factors that affect friction. In task 2 they are asked to design an experiment which will test one of those factors. This is probably the area which students will find most difficult. The following is a list of some suggestions they may put forward and some ideas as to how they may be tested. In the spirit of a student lead enquiry the teacher is encourage not to simply tell the students how to conduct the investigation. However it is recognised that classes contain mixed ability pupils. For those students that are struggling with the openness of the enquiry the teacher may guide them towards an easier investigation.

Task 3 is to be carried out in a different session from tasks 1 and 2. This is done deliberately to allow the teacher time to prepare the equipment necessary for task 3.

When the road is wet or dry.

Some students will realise that lubrication reduces friction between two surfaces. The following is one method that could be used to test this factor.

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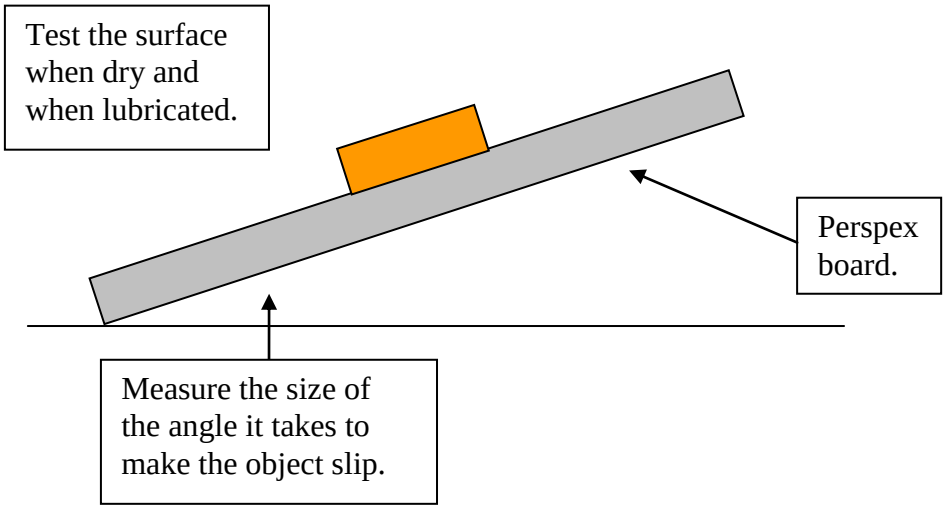

Figure 3

How Heavy the Bus is.

Some students will recognise that the weight of the bus may be a factor. The following are some suggested methods.

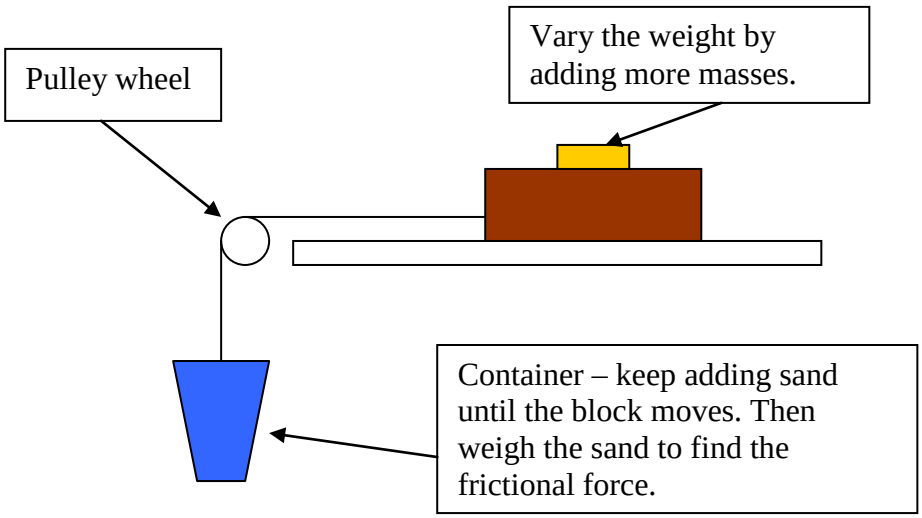

Figure 4

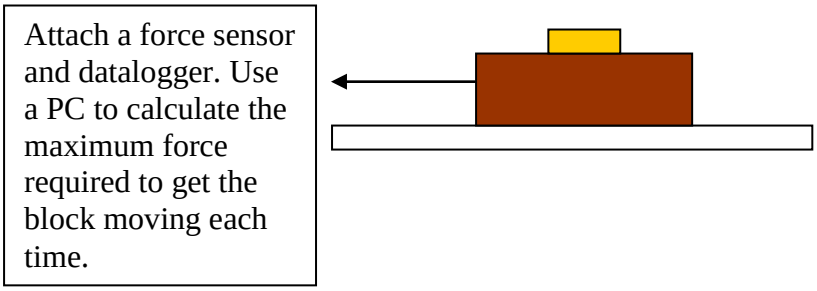

Figure 5

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How Quickly the Bus Turns / How Tight a Turn is.

Some students might suggest that the tighter the turn is or the faster a bus tries to take the turn the more difficult it will be for the tires to grip the road. The following is a suggested method for investigating this.

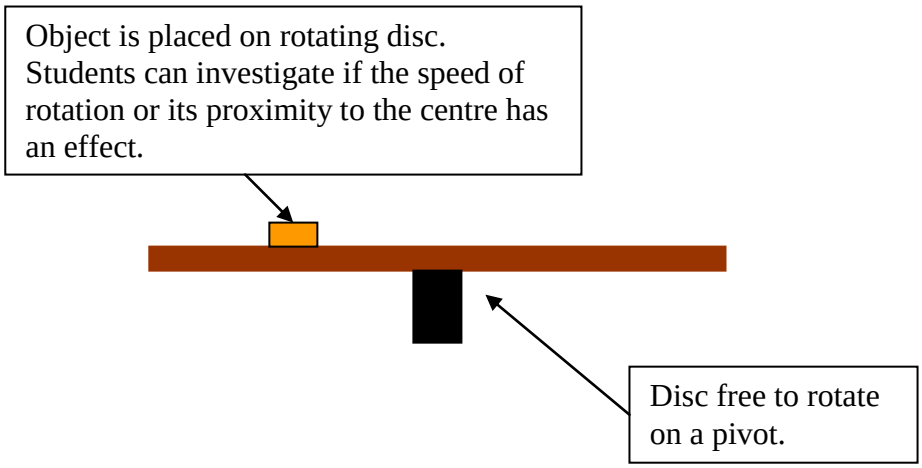

Figure 6

For an object to continue moving in circular motion it requires a centripetal force to hold it in place. In the case of the object above this centripetal force is supplied by the friction between the object and rotating disc. The size of this force is given by:

$$F = \frac{mv^2}{r} \quad \text{or} \quad F = mr\omega^2$$

Where:

m = mass of the object.

v = speed of the object.

r = radius of the turn (distance from centre to object).

ω = angular velocity of the object.

The methods listed above are merely suggestions. It is hoped that students will be able formulate their own investigations but in instances where students are struggling the teacher can use some of these methods to help guide students.

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Assessment

It is suggested that assessment be both formative and summative. In the case of formative assessment 'comment only' or 'allocation of marks/grade' may be made at the discretion of the teacher. The following tables 1 and 2 may be used by the teacher to evaluate each student's performance in terms of performing the activity and working within the group.

Student Group work Evaluation based on Teacher Observation

Student Name_____ Class_____

	Teacher Comment/ Mark/Grade
Functioning in the group	
Contributes to the group discussion during the learning the subject	
Has patience for the group's members	
Knows and understands the objectives of the activity (active observation)	
Thinks in a creative manner and exhibits vision	
Presenting the activity orally	
Presents the activity in a clear and practical manner	
Shows triangulation of evidence	
Presents knowledge and understanding of the subject	
Uses precise and proper scientific language	

Table 1

Ref: The Weizmann Institute of Science, Rehovot, PARSEL

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Student Assessment Tool based on the Teacher's Observations

Performing the activity	Teacher Comment / Mark / Grade
Performs the activity according to the instructions/plan created	
Maintains an orderly and clean work table	
Understands the objectives of the activity and knows which tests and measurements to perform	
Uses lab tools and the measurement equipment in a safe and appropriate manner	
Behaves in a safe manner	

Functioning as group member	
Contributes to the group discussion during the theoretical inquiry phases (raises questions and hypotheses, designs the experiment, draws conclusions, makes justified decisions)	
Shows tolerance with, and gives encouragement to, the group members.	
Cooperates with others in a group and fully participates in the work of the group.	
Illustrates leadership skills –guiding the group by thinking creatively and helping those needing assistance (cognitive or psychomotor); summarising outcomes.	

Presenting the experiment orally to the rest of the group	
Presents the activity in a clear and practical manner with justified decisions.	
Presents by illustrating knowledge and understanding of the subject.	
Uses precise and appropriate scientific terms and language.	

Table 2

Ref: Jack Holbrook, ICASE, PARSEL

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