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Cambridge Checkpoint Science

Teacher's Resource

SAMPLE

9

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Completely Cambridge
Cambridge resources for Cambridge qualifications

Overview of the course

The *Cambridge Checkpoint 9* Coursebook and Workbook provide complete coverage of the requirements of Stage 9 of the Cambridge Secondary 1 Science course. The materials on this CD-ROM provide guidance in the use of the *Cambridge Checkpoint 9* Coursebook and Workbook. In addition, there are further resources that can be used in teaching the course. *Cambridge Checkpoint* provides a firm base from which students can build their knowledge and skills as they work towards the progression tests at the end of Stages 7 and 8, and eventually the Checkpoint examination at the end of Stage 9.

The materials are divided into eleven units, each corresponding to one or more main areas of the Cambridge Secondary 1 Science curriculum framework. Each unit is then split into topics. Most topics cover a two-page spread in the Coursebook, with a few covering three pages. As well as the material in the Coursebook, there are more support materials in the form of exercises in the Workbook, and worksheets and animations on this Teacher's Resource CD-ROM.

The teaching ideas sections on this CD-ROM provide suggestions about how you might use the materials to cover the complete set of learning objectives in the Cambridge Secondary 1 Science curriculum framework. The number of lessons you spend on each topic will depend very much on the situation in your school – for example, the previous experience of your students, the constraints of the timetable and the availability of laboratories. You may choose to condense some topics into a smaller number of lessons than suggested in the teaching ideas, or to extend others – particularly where you wish to spend time on the development of scientific enquiry skills (see below).

Active learning

A key feature of the Cambridge Secondary 1 Science course is the active involvement of students in their learning. The materials in the Coursebook, Workbook and worksheets provide numerous opportunities for students to do practical work, take part in discussions, ask questions, research and present information, and assess their own work and that of their peers against a set of criteria. Research shows that such involvement significantly improves both knowledge and understanding.

Scientific enquiry skills

The Cambridge Secondary 1 Science course places a strong emphasis on the development of scientific enquiry skills. These are addressed throughout the Coursebook, Workbook and worksheets. Activities in the Coursebook that help students to develop their scientific enquiry skills are marked with the symbol SE.

The table below summarises components of the course where each of the skills listed in the Cambridge Secondary 1 Science curriculum framework are addressed.

Framework statement	Coursebook	Workbook	Teacher's Resource
Ideas and Evidence			
Discuss the importance of questions, evidence and explanations, using historical and contemporary examples	Activity 3.8		
Test explanations by using them to make predictions and then evaluate these against evidence	Activity 1.7B	Exercise 1.1	
Discuss the way that scientists work today and how they worked in the past, including reference to experimentation, evidence and creative thought	Activity 3.8		
Plan investigative work			
Select ideas and produce plans for testing based on previous knowledge, understanding and research	Activities 1.7B, 2.2, 2.3, 5.2, 6.3A, 6.3B, 6.5A, 6.5B	Exercises 6.3, 6.5	Worksheets 1.5, 2.5, 5.2B, 10.5

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Framework statement	Coursebook	Workbook	Teacher's Resource
Suggest and use preliminary work to decide how to carry out an investigation	Activities 5.2, 8.4B, 8.5A, 10.2	Exercises 5.3	Worksheets 3.6
Decide whether to use evidence from first hand experience or secondary sources	Activity 2.4	Exercises 2.3	
Decide which measurements and observations are necessary and what equipment to use	Activities 1.2, 1.7B, 2.2, 5.2, 6.3, 6.5, 8.2, 8.3B, 8.4, 8.5A, 9.2, 10.2, 10.4	Exercise 2.3, 5.3, 6.3, 6.5, 8.5, 8.6, 9.2	Worksheets 1.5, 2.5, 5.2B, 8.6A, 9.2, 10.5
Decide which apparatus to use and assess any hazards in the laboratory, field or workplace	Activities 1.1, 1.7B, 2.3, 2.4, 5.2, 6.3, 6.5, 7.2, 7.3, 7.4, 8.2, 8.4A, 8.4B, 8.4C, 8.5A, 9.2, 9.5, 9.8	Exercises 5.3, 6.3, 7.2, 7.3, 7.4, 8.6	Worksheets 1.5, 2.5, 9.2, 10.5
Use appropriate sampling techniques where required	Activity 2.3	Exercise 2.3	Worksheet 2.3A
Obtain and present evidence			
Make sufficient observations and measurements to reduce error and make results more reliable	Activities 1.2, 1.7B, 2.2, 2.3, 6.3, 8.2, 8.3, 8.4A, 8.4B, 8.4C, 8.5B, 9.7		Worksheets 1.5, 10.5
Use a range of materials and equipment and control risks	Activities 1.1, 1.7B, 2.2, 2.3, 5.2, 6.1, 6.2, 6.3, 6.5, 6.6, 7.2A, 7.2B, 7.3, 7.4, 8.2, 8.3A, 8.4A, 8.4B, 8.4C, 8.5B, 8.6, 9.2, 10.1A, 10.1B	Exercises 6.3, 7.2, 7.3, 7.4	Worksheets 1.1, 1.5, 5.2B, 5.5, 7.2, 8.6A
Make observations and measurements	Activities 1.2, 1.3, 1.4, 1.5, 1.6, 1.7A, 1.7B, 2.1, 2.2, 2.5, 3.2, 5.2, 5.3, 5.4, 6.1, 6.2, 6.3A, 6.3B, 6.5A, 6.5B, 6.6, 7.2A, 7.2B, 7.3, 7.4, 8.2, 8.3A, 8.3B, 8.4A, 8.4B, 8.4C, 8.5B, 8.6, 9.1, 9.5, 10.1A, 10.1B, 10.5A, 10.5B, 10.8A, 10.8B	Exercises 1.4	Worksheets 1.1, 1.4, 2.1, 2.5, 2.7, 3.2A, 3.6, 5.2B, 10.5
Choose the best way to present results	Activities 1.2, 1.3, 1.7B, 2.2, 2.3, 2.5, 5.2, 6.3A, 6.3B, 6.5A, 6.5B, 9.5, 9.8, 10.8B End of unit questions 3c	Exercises 1.3, 6.3	Worksheets 1.2A, 1.5, 2.5, 2.7, 3.6, 5.1, 5.2B, 5.3, 5.5
Consider evidence and approach			
Describe patterns (correlations) seen in results	Activities 1.3, 1.7B, 2.2, 2.3, 3.2, 4.3, 4.4, 5.2, 6.1, 6.2, 6.3, 6.5, 8.1, 8.2, 8.3A, 8.3B, 8.4A, 8.4B, 8.4C, 8.5B, 9.8, 10.4, 10.6 End of unit questions 3D, 4.1, 5.2	Exercise 1.2, 1.3, 3.3, 4.4, 6.2, 6.3, 8.2, 8.3, 8.4, 8.5	Worksheets 1.2A, 1.7B, 2.5, 2.7, 3.2A

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Framework statement	Coursebook	Workbook	Teacher's Resource
Interpret results using scientific knowledge and understanding	Activities 1.3, 1.7B, 5.2, 6.3A, 6.3B, 6.5A, 6.5B, 6.6, 8.1, 8.2, 8.3B, 8.4A, 8.4B, 8.4C, 8.5B, 8.6, 10.5B, 10.7 End of unit questions 5.2	Exercises 1.2, 1.3, 3.3, 5.2, 6.2, 8.2, 8.3, 8.4, 8.5	Worksheets 1.1, 1.7B, 2.5, 2.7, 5.1, 5.2B, 5.3, 8.2, 8.5, 10.5
Look critically at sources of secondary data	Activity 2.3 End of unit questions 5.2	Exercises 1.2, 2.9, 3.3, 5.2, 5.4	Worksheets 1.2A, 1.7B, 5.1, 5.3
Draw conclusions	Activities 1.3, 1.7B, 2.2, 2.3, 4.3, 5.2, 5.4, 6.1, 6.2, 6.3, 6.5, 6.6, 8.1, 8.2, 8.3B, 8.4A, 8.4B, 8.4C, 8.5B, 8.6, 9.7, 10.2, 10.5A, 10.5B, 10.6 End of unit questions 3D, 4.1, 5.2, 5.3, 8.3	Exercises 1.2, 3.3, 4.4, 5.2, 6.3, 8.2, 8.3, 8.4, 8.5	Worksheets 1.1, 1.2A, 1.7B, 2.5, 3.2A, 3.6, 5.1, 5.2B, 5.3, 8.5, 10.5
Evaluate the methods used and refine for further investigations	Activities 1.7B, 9.1, 9.7, 13.2 End of unit questions 2.3, 2.4, 3.3, 13.4	Exercises 3.3, 5.2, 5.3, 6.3, 6.5	Worksheets 1.7B, 2.5, 2.7, 3.2A, 5.1, 5.2B, 5.3, 5.5
Compare results and methods used by others	Activities 2.2, 5.2, 9.7	Exercise 6.3	Worksheets 2.5, 5.3
Present conclusions and evaluation of working methods in different ways	Activity 1.7B	Exercises 5.3, 8.4	Worksheets 1.7B, 2.7, 3.2A, 5.3
Explain results using scientific knowledge and understanding. Communicate this clearly to others	Activities 1.3, 1.7B, 5.2, 6.5A, 6.5B, 6.6, 8.2, 8.3B, 8.4A, 8.4B, 8.4C, 8.5B End of unit questions 5.2	Exercises 1.2, 6.3, 6.5, 8.3, 8.5	Worksheets 1.1, 2.5, 2.7, 5.2B, 5.3

Knowledge and understanding, and application and implication

As well as scientific enquiry skills, the Progression tests and Checkpoint examination test students' knowledge and understanding and their ability to apply this knowledge in unfamiliar situations. Students therefore need to develop the confidence and ability to think through answers to questions, rather than always relying on simply recalling information. Using knowledge in this way is a higher level skill than simply remembering facts, and students need regular practice if they are to improve. Questions in the Coursebook that help students to develop application and implication skills are marked with the symbol A+I. Many of the exercises in the Workbook are also designed to help students to improve their skills in this area.

Teaching sequence

The materials in the Coursebook and Workbook are arranged in the same sequence as in the Cambridge Secondary 1 Science curriculum framework. All of Biology comes first, followed by Chemistry, and finally Physics. This may be how you choose to cover the material in the Stage 9 course. However, there are many other possible routes through it, and you can use the materials in different orders to follow your own scheme of work.

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The choice of route through these materials will largely be determined by the way in which the Secondary 1 Science course is timetabled. This could be either:

- teaching Biology, Chemistry and Physics each week throughout the year:

Unit 1		→	Unit 2		→	Unit 3		
Unit 4	→	Unit 5	→	Unit 6	→	Unit 7	→	Unit 8
Unit 9		→	Unit 10		→	Unit 11		

- or teaching first one, then the second and then the third subject during the year, in whichever order you choose, for example:

U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11

or

U6	U7	U8	U9	U10	U11	U1	U2	U3	U4	U5

or

U9	U10	U11	U1	U2	U3	U4	U5	U6	U7	U8

Any of these arrangements can be accommodated using these materials. However, it is recommended that you follow the units in each subject area in numerical order, as the materials have been designed to provide steady progression in skills throughout each subject.

Whichever route is chosen, it will be important to consider how the scientific enquiry strand is dealt with. These materials provide for progression through this strand within each subject area. Decisions will need to be made about how time is allocated for activities that develop scientific enquiry skills within each subject area, as this will affect the number of lessons that are required to cover each unit.

Animations

There is a selection of animations available on this CD-ROM. A few of these are directly related to the content of the individual topics, and can be found alongside all other resources for those topics. Their content is described in the teaching ideas where appropriate. There is also a selection of more general animations that can be used to develop scientific enquiry skills, which can be found in a separate section of the CD-ROM. Some of these use examples that are related to either biology, chemistry or physics, so you may want to use them in these contexts. The full list, with brief descriptions, is given below. Some of these animations contain material that goes beyond the content of the Coursebook. This can be a way of bringing extension into your lessons, but it is also straightforward to skip this content if you do not consider it appropriate.

Available scientific enquiry animations

Planning and carrying out investigations

G1 Different types of evidence

This animation describes how an investigation can be approached using different strategies and by asking different questions.

G2 Preliminary work I

Students are given the results of preliminary work for an investigation and asked to make the aim of the investigation more specific.

G3 Preliminary work II

In this animation, students are asked to use the results of preliminary work to decide the amounts of chemicals to use and the number of measurements to take in an example investigation.

G4 Reliable evidence

This animation discusses variables that can be difficult to control and which can affect the reliability of the evidence obtained.

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G5 Appropriate equipment

Students are asked to score four ideas for investigations with regard to the appropriate use of equipment.

G6 Trial runs

This animation describes the use of trial runs, and asks students to describe the problems that each of five trial runs reveals in the method. The students are also asked to suggest improvements to the method.

G7 Variables

Students must identify the independent and dependent variable in five different investigations.

G8 Databases

In this animation, students will use an example database to suggest which plants could be planted in four different gardens.

G9 Reliability I

Using three example investigations, this animation shows that experiments must be repeated to obtain reliable evidence.

G10 Reliability II

In this activity, students are asked different questions about a set of results to help show how they can be used to check reliability.

G11 Variables (circuits)

This animation provides examples to help students decide which factors must be controlled to ensure that an investigation is fair.

G12 Anomalous results I

In this animation, students are shown the results for six investigations and asked to select the anomalous result for each set of results. They are also asked to give a reason for their choice.

G13 Models

This animation shows how models can be used to enhance understanding in investigations.

G14 Making predictions

In this activity, students are asked to describe the patterns in data from five different investigations. The students must then use the patterns to make predictions.

G15 Precise measurements

Students are shown different pictures of methods for measuring time and are asked to sort the methods from the most precise to the least precise. The students are also asked to match the method to a suitable investigation.

Interpreting and presenting results

G16 Conflicting evidence

In this example, students are asked to look at conflicting evidence for two investigations. They are then asked to describe what each piece of evidence tells them and to make a conclusion that supports the evidence chosen.

G17 Quantitative data I

Students are asked to answer questions on the quantitative results of four investigations.

G18 Quantitative data II

Students are asked to put sets of quantitative data into suitable tables and draw appropriate graphs of the results.

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G19 Additional evidence

In this example, students are asked to explain how well the evidence provided for three investigations supports the conclusions, and to select suitable additional evidence that is needed.

G20 Qualitative data I

Students are asked to answer questions on the qualitative results of five investigations.

G21 Qualitative data II

Students are shown five different ways of presenting the results from the investigation and are asked to describe the good and bad points of each method of presentation. They must also place each way of presenting the results in order of the most to the least appropriate.

G22 Quality of evidence

In this activity, students are shown a piece of evidence from two investigations. They need to identify the strengths and weaknesses in the evidence to determine how well the conclusion is supported.

G23 Complex patterns

This animation includes a drag-and-drop activity to help students to deal with complex patterns in investigations.

G24 Anomalous results II

In this activity, students are shown the results of four investigations looking at balancing forces. The students are asked to identify and explain the anomalous result for each investigation.

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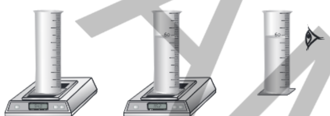
Unit 9 Forces in action

Topic 9.1 The idea of density

1 a kilogram (kg)
  b They have they same mass (1 kg).
2 a density of gold = $19.3\ g / cm^3$
  b Water is denser than ice.
3 The density of water decreases when it becomes steam. The same mass of particles now occupies a bigger volume so the density is less.

Topic 9.2 Measuring density

1 150 g
2 a



  b 61.2 g
  c $1.02\ g / cm^3$

Topic 9.3 Density calculations

1 a $7.8\ g / cm^3$
  b The atoms are packed more closely together in steel than in iron. (There is less empty space in steel.)
2 a 450 g
  b 530 g
3 $1.25\ cm^3$

Topic 9.4 Pressure

1 The heavy person standing on the bed creates greater pressure
2 a The pressure is lower because the large force presses on a big area, so the truck will not sink in the sand.
  b It will be easier to press into the ground because the pushing force acts on a small area, creating a greater pressure.
  c The point is sharp so there is a greater pressure (force acting on small area); the head has a large area so that the force acts on a bigger area, creating less pressure on the thumb when you push.

Topic 9.5 Pressure calculations

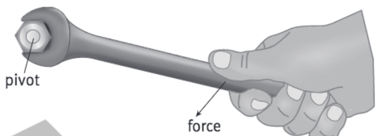
1 force = 3 N; pressure = $3\ N / m^2 = 3$ Pa
2 pressure = $12\ N / cm^2$
3 force = 7000 N

Topic 9.6 Pressure in gases and liquids

1 The water at the bottom of the bottle is under greater pressure than the water at the top because there is more water pressing down on it. This means that the force pushing it out of the bottle is greater, and so it has a greater speed.
2 force = 200 000 N

Topic 9.7 The turning effect of a force

1



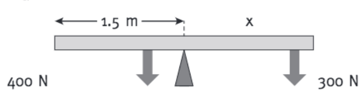
  a The scales are tipped down on the side with the weights.
  b

Topic 9.8 The principle of moments

1 clockwise
2 The girl must move towards the pivot so that the turning effect of her weight is less.
3 The boy could move backwards, or carry a heavy weight.

Topic 9.9 Calculating moments

1 a The 100 N force has a clockwise moment
  b 40 N m
  c 40 N m
  d clockwise moment = anticlockwise moment; so the beam is balanced
2 a



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b 2.0 m

c 120 N

End of unit questions

9.1 **a** Ice and paraffin wax would float in water because they are less dense than water. [3]

b Copper would have more volume because it is less dense than lead. [2]

9.2 **a** 8 cm^3 [2]

b 20.8 / 8 = 2.6 g / cm^3 [2]

9.3 **a** 200 cm^2 [1]

b pressure = 23 / 200 = 0.115 N / cm^2 [2]

c Volume has decreased. [1]

d The particles collide with the walls more frequently. [1]

9.4 **a** 60 × 0.2 = 12 N m [2]

b anticlockwise [1]

c F = 20 × 1.2 / 0.5 = 48 N [3]

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Unit 9 Forces in action

Exercise 9.1 Understanding density

1 cork (least dense)
nylon
concrete
marble
copper
silver
gold (most dense)

2 ice (least dense)
brick
iron
lead (most dense)

3 1 kg of silver has a greater volume than 1 kg of gold because silver is less dense than gold.

4 An atom of gold has more mass than an atom of silver.

Exercise 9.2 Measuring density

1 **a** 8.5 cm
b 2.0 cm
c 8.5 cm^3

2 **a** 23 cm^3
b 8.5 g/cm^3
c The density of brass is closest to the measured value. He cannot be sure, however, because there might be other metals (or alloys) not included in the table with a similar density.

3 **a** To stop the foam floating; it must be completely submerged.
b 55 cm^3
c 0.12 g/cm^3 (Note: The density of polystyrene foam varies from one piece to another.)

4 Yes, Pat is right; people are less dense than water. People float in water – this is good evidence. It isn't essential to measure the density of a person.

Exercise 9.3 Calculations involving density

1 **a** 72 m^3
b 93.6 g

2 **a** volume = 8000 cm^3, mass = 61 600 g = 61.6 kg

3 35 cm^3

4 **a** 1 g
b 20 g
c 10 cm^3
d 22.5 cm^3
e **i** 60 cm^3
ii 48.0 g
iii 0.80 g/cm^3

5 mass of mercury = 50 × 13.6 = 680g
∴ total mass of bottle plus mercury is 680g + 25g = 705g

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Exercise 9.4 High pressure, low pressure

1 Stiletto heels have a small **area**, so the **force** of the person's weight causes high **pressure** on the floor. A low **pressure** is desirable so as not to damage the wooden floor.

2 A butcher needs high **pressure** to cut meat. To do this, the edge of the knife must be sharp, so that it has a small **area** that the **force** of the butcher is pressing on.

3 The sharp point has a small **area**, so that the **pressure** is high when pushing through the fabric.

The thimble spreads the **force** over a large **area** of the sewer's finger, causing a small **pressure** so they will not be hurt.

Exercise 9.5 Calculations involving pressure

1 **a** Pa N/cm^2 ~~kg/cm^3~~ N/m^2 pascal ~~g/cm^2~~

b Pa, N/m^2 and pascal are all equivalent.

2 **a** 0.4 m^2

b area of feet = 0.4 m^2; pressure = 60 000/0.4 = 150 000 N/m^2

c area of feet = 0.3 m^2; pressure = 60 000/0.3 = 200 000 N/m^2

3 **a** 9.0 m^2

b 36 000 N

4 **a** 1.6 m^3

b 3840 kg

c 38 400 N

d 3.2 m^2

e 12 000 N/m^2

5 **a** estimate of weight = 50 kg × 10 = 500 N

area of foot is approximately 0.10 m × 0.25 m = 0.025 m^2

Pressure = 500 / 0.025 = 20 000 N/m^2

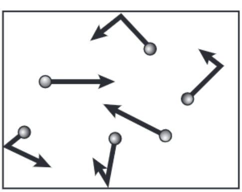
b This is much less than the pressure of an elephant on the ground – about one-tenth.

Exercise 9.6 Gas pressure

1 **a** Perhaps 5 m / s

b Air particles move 800 times as fast (answer depends on part a)

2



3 **a** Speed increases

b More frequently

c Bigger force

d Increase

4 Room is smaller, so collisions with walls will be more frequent, therefore pressure will increase.

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Exercise 9.8 Moments of forces

1 400 N m clockwise

2 20 N m; 20 N m; 24 N m (greatest)

3 On left: 600 N m anticlockwise; on right: 600 N m clockwise; it is balanced

Exercise 9.9 Balancing moments

1

2 **a** 120 N m

b 0.8 m

3 Position c (5 × 1 = 1 × 5).

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Unit 9 Forces in action

Worksheet 9.2 Density techniques

1

Material	Polystyrene foam
width (*w*) in cm	4.0
height (*h*) in cm	3.0
length (*l*) in cm	5.0
volume ($V = w \times h \times l$) in cm³	60
mass (*m*) in g	7.80
density (*m* / *V*) in g/cm³	0.13

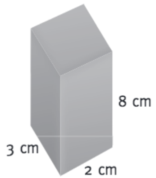
2 The answers will depend on the blocks that the students measure.

3

Material	Water
mass of empty measuring cylinder (m_1) in g	240
mass of measuring cylinder with liquid (m_2) in g	410
mass of liquid (*m*) in g	170
volume of liquid (*V*) in cm³	170
density (*m* / *V*) in g/cm³	1.0

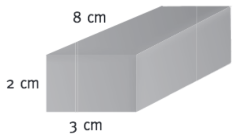
Worksheet 9.5 Changing pressure

1 4.0 N / cm²



The surface with the smallest area is in contact with the floor, to concentrate the weight over the smallest area.

2 1.0 N / cm²



The surface with the largest area is in contact with the floor, to spread the weight over the biggest area.

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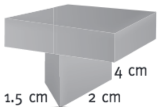
3 10.0 N / cm^2



The weights of the two blocks are both pressing down on the smallest area. (The orientation of the top block does not matter, as long as it balances on the lower block.)

Worksheet 9.8 Beam balancer

1 Students' results will depend on the forces and distances they have chosen.

2 The first three rows of the table will be as follows:

Force on left of pivot			Force on right of pivot		
1	2	3	4	5	6
Force/N	Distance from pivot/cm	Moment of force/N cm	Force/N	Distance from pivot/cm	Moment of force/N cm
1	20	20	2	10	20
1	30	30	2	15	30
3	20	60	4	15	60

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Unit 9 Forces in action

These notes contain guidance on the preparation and use of apparatus and materials for practical activities. Activities, Worksheets and Workbook exercises that do not involve practical work are not included. Although great care has been taken in checking the accuracy of the information provided, Cambridge University Press shall not be responsible for any errors, omissions or inaccuracies.

Teachers and technicians should always follow their school and departmental safety policies. You must ensure that you consult your employer's model risk assessments and modify them as appropriate to meet local circumstances before starting any practical work. Risk assessments will depend on your own skills and experience, the skills and experience of your students, and the facilities available to you. Everyone has a responsibility for his or her own safety and for the safety of others. The notes below point out any significant hazards and give suggestions for how to reduce risk, while assuming a basic level of laboratory 'good practice' regarding safety. They should not be regarded as risk assessments.

Practical activities should be carried out by teachers themselves before they are presented to students.

Activities in Coursebook

Activity 9.1 Judging density

Each pair or group will need:

* access to a selection of samples of materials of different densities; for example, pieces of wood, cardboard, glass, expanded polystyrene (Styrofoam), polythene, aluminium, steel, brass, china, stone, brick etc.

Note that items such as a glass lens or the steel rod from a clamp stand are suitable, but you should select items that are made of one material.

You will need to know the density of each material, although the students are only expected to judge relative densities by handling the materials. They will find this easier if samples are of similar sizes, but this is not essential. This could be a point for discussion, since it leads to the idea of 'fair testing' of the materials.

SAFETY! **Check that none of the samples has any sharp corners or edges, and that they are unlikely to break if dropped.**

Activity 9.2 Density measurements

Each pair or group will need:

* samples of some solid materials in the form of rectangular blocks, e.g. expanded polystyrene, wood, glass
* irregularly-shaped samples of solid materials, e.g. metal, stone (a pebble), glass, plastic
* water and another liquid e.g. cooking oil
* access to a top pan balance for measuring masses
* a measuring cylinder
* a ruler

It will help if the samples are labelled with the material of which they are made.

The measuring cylinder must be big enough to allow the immersion of the irregularly-shaped samples; for samples which float, students can use the pebble to keep them submerged in water.

Activity 9.3 Measuring the density of a gas

You will need:

* a large, rigid plastic container, such as an empty water container from a water cooler
* a bung fitted with metal tube, rubber tubing and clip valve
* a vacuum pump and tubing to allow attachment to the plastic container
* a supply of water
* a large measuring cylinder
* access to a top pan balance for measuring masses

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To measure the change in mass when the air is pumped from the container, the balance should weigh to within 0.01 g or better.

The pump should be able to reduce the pressure in the container to a small fraction of atmospheric pressure.

The plastic container must be rigid; a metal can could be used but a transparent plastic container is better. Do not use a glass or brittle plastic container as this may break when the air is pumped out.

An alternative to pumping out the air is to pump air in using a foot pump (as used to inflate car tyres); this will increase the mass of the container. Release the excess air and collect it over water in a measuring cylinder to find the volume.

Activity 9.5 Squashing foam

Each pair or group will need:

* two or three rectangular blocks of plastic foam – the sort of material used in seat cushions
* thin pieces of wood cut to have the same dimensions as the upper faces of the foam blocks
* a selection of weights – 1, 5 and 10 N
* a ruler

Select foam which can squash easily. Cut blocks roughly 10 × 10 × 20 cm, and pieces of plywood 10 × 10 cm. The foam should compress quite significantly when weights are placed on top.

Activity 9.7 Scale maker

Each pair or group will need:

* a length of wood similar to a ruler, perhaps 40–50 cm in length; mark the midpoint with a thin line
* a piece of wooden rod, approximately 5 cm in length, to act as pivot
* a selection of six small items, with weights ranging between 0.5 N and 2 N
* a 1.0 N weight (e.g. a 100 g mass)
* a ruler

You could use a ruler as the beam and a pencil as the pivot, but it is better to use an unmarked piece of wood as the beam.

Students should start by comparing weights, perhaps by placing pairs of objects at opposite ends of the balanced beam to find which is the heaviest. An alternative approach is to place the lightest weight at one end and to find where each of the others must be placed to balance it.

Given a single 1 N weight, they may then be able to devise a way of measuring weights (this requires students to have an intuitive grasp of the principle of moments).

Activity 9.8 Balancing a beam

Each pair or group will need:

* a length of wood similar to a ruler, perhaps 40–50 cm in length; mark the midpoint with a thin line
* a piece of wooden rod, approximately 5 cm in length, to act as pivot
* a number of 1 N weights (e.g. 100 g masses)
* a ruler

As in Activity 9.7, Scale maker, you could use a ruler as the beam and a pencil as the pivot, but it is better to use an unmarked piece of wood as the beam.

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Unit 9 Forces in action

Possible lessons

Topic	Number of 40-minute periods	Outline of lesson content	Resources in Coursebook	Resources in Workbook	Resources on Teacher's Resource
9.1 The idea of density	1	Review of mass *versus* weight; density as a measure of heaviness of a material	Questions 1–3 Activity 9.1, Judging density	Exercise 9.1, Understanding density	
9.2 Measuring density	1	Methods for measuring mass and volume; calculating density	Questions 1–5 Activity 9.2, Density measurements	Exercise 9.2, Measuring density	Worksheet 9.2, Density techniques
9.3 Density calculations	1	Calculating mass, volume and density	Questions 1–3 Activity 9.3, Measuring the density of a gas	Exercise 9.3, Calculations involving density	Worksheet 9.3, Density calculations
9.4 Pressure	1	The meaning of pressure	Questions 1–2 Activity 9.4, Cricket stumps	Exercise 9.4, High pressure, low pressure	
9.5 Pressure calculations	1	Calculating pressure from force and area	Questions 1–3 Activity 9.5, Squashing foam	Exercise 9.5, Calculations involving pressure	Worksheet 9.5, Changing pressure
9.6 Pressure in gases and liquids	1	Pressure in fluids, in terms of the particle model of matter	Questions 1–2 Activity 9.6, Pressure and particles	Exercise 9.6, Gas pressure	
9.7 The turning effect of a force	1	The idea of a force causing an object to turn about a pivot	Questions 1–2 Activity 9.7, Scale maker		
9.8 The principle of moments	1	Defining 'moment' and understanding how equal and opposite moments result in balance	Questions 1–2 Activity 9.8, Balancing a beam	Exercise 9.8, Moments of forces	Worksheet 9.8, Beam balancer
9.9 Calculating moments	1	Calculations involving moments, forces and distances	Questions 1–3 Activity 9.9, Moment challenge	Exercise 9.9, Balancing moments	
End of unit questions			Questions 1–4		

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Topic 9.1 The idea of density

This topic introduces the idea of density. Rather than giving an equation to define density, it describes density as a 'fair test' way of comparing the heaviness of different materials. It is the mass of 1 cm^3. It also considers how we can picture different densities in terms of the particles from which materials are made.

Ideas for the lesson

- You could begin with the standard 'trick question' – 'Which is heavier, a tonne of lead or a tonne of feathers?'. Discuss the different volumes associated with these quantities. (A tonne of lead occupies about 90 litres; a tonne of feathers is mostly air and might occupy a whole room.)
- Now consider how we might do a fair test of the 'heaviness' or 'lightness' of materials. We need to consider a standard volume – one cubic metre, or one cubic centimetre.
- The Coursebook shows centimetre cubes of a range of solid materials. You can emphasise how this allows us to compare different materials. Discuss what students would notice if they were to lift blocks of these materials.
- Allow students to carry out Activity 9.1, Judging density. Students lift and hold samples of different materials and attempt to judge their relative densities. People are surprisingly good at this, even if the samples are of different masses and volumes. Students should try to put the samples in order of density.
- Continue with a discussion of the measurements you could make to decide unambiguously the ranking of densities. This will lead into measurement of mass and volume in the next topic.
- Finish the topic by asking students to recall the particle model of matter. Can they use it to explain why gases are generally much less dense than solids? Why do solids and liquids have similar densities? There are two parts to the answer. Most importantly, the particles are arranged differently; in gases, there is a lot of empty space between the particles. A minor issue, which you may not wish to discuss, is that the particles themselves may have different densities. Gold atoms are the same size as silver atoms, but their mass is greater, so gold is denser than silver.

Common misunderstandings and misconceptions

- Students need to appreciate that the term 'density' can apply to a material; we use it as a way of comparing different materials. It is often acceptable to talk about 'light' or 'heavy' materials, but it is better to reserve these terms for describing specific objects rather than materials.
- Some students may imagine that a gas has no mass. Point out that water boils to become steam, and can condense back to water. The mass of the particles remains constant.
- At this point, you may wish to revise the distinction between mass and weight. Density is to do with how concentrated the mass of a material is; material has the same density whether it is on the Moon, outer space, etc.

Homework ideas

- Workbook exercise 9.1, Understanding density

Topic 9.2 Measuring density

This topic considers how density is measured. This involves techniques for measuring mass and volume, including objects with regular and irregular shapes.

Ideas for the lesson

- Follow on from the previous topic by asking: 'What quantities do we need to measure to find the density (mass of 1 cm^3) of a material?'.
- Discuss how to measure mass. Check that students are familiar with the available balances. Show how to use a tare button, if available. Show also how to measure the mass of a liquid by weighing first the container and then adding the liquid.
- Go on to discuss measurement of the volume of a regular solid. It is probably best to consider rectangular blocks, but you could also consider cylinders if your students' maths is adequate.
- Next consider irregular solids and demonstrate how to measure volume by displacement of water. A material that floats (e.g. cork) must be weighted down so that it is submerged.
- Check that students understand how to calculate density from mass and volume.

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- Students can now carry out Activity 9.2, Density measurements. Once students understand the method, it is a good idea to concentrate on obtaining answers that are as accurate as possible by taking great care with measurements.
- Worksheet 9.2, Density techniques, can be used to structure this activity. It includes data for two density measurements.
- The Coursebook goes on to consider floating and sinking in relation to density. A material which is less dense than water will float. It is useful for students to memorise the density of water (1 g / cm^3), and to think of other densities relative to this. This section could be left for homework.

Common misunderstandings and misconceptions

- Archimedes' principle is often taught at this stage. This is because his original observation (that a gold crown would have a different volume to a silver crown with the same mass), depends on an understanding of density. However, to extend this to the idea of the force of upthrust equal to weight of displaced water is rather demanding and is not relevant here.

Homework ideas

- Workbook exercise 9.2, Measuring density
- Coursebook questions 1 and 2

Topic 9.3 Density calculations

In this topic, students use the equation which defines density to calculate mass and volume.

Ideas for the lesson

- Start by recapping the equation or formula, which defines density. Check that students can rearrange the equation to make mass or volume its subject.
- You could show a couple of sample calculations on the board, or use the examples in the Coursebook. Students can then tackle questions 1 and 2 from the Coursebook.
- Once you are confident that students can do these calculations, you can ask them to devise their own questions and answers – see Worksheet 9.3, Density calculations. When students are satisfied that they have the correct answers, they can swap their questions with a partner. You could choose one or two good examples to show to the whole class.
- It is important to emphasise the need to understand an equation like the one for density, rather than learning it unthinkingly. Students will find it easier to rearrange it correctly if they have understood it. One approach is to think in terms of its units – g / cm^3, which should remind students that density is calculated by dividing mass by volume.
- Activity 9.3, Measuring the density of air, will help to emphasise how density is calculated. Some students will find it hard to believe that air has mass (and therefore density), so you may wish to remind them of the particulate nature of gases.
- Workbook Exercise 9.3, Calculations involving density, gives further practice and could be used in class.

Common misunderstandings and misconceptions

- Students can easily become confused when rearranging an equation. This takes practice, but students should also be able to look at their answers and decide whether they are realistic. In particular, it can help to relate things to the density of water, 1 g / cm^3.

Homework ideas

- Coursebook questions 1–3
- Workbook exercise 9.3, Calculations involving density

Topic 9.4 Pressure

In this topic, students develop an understanding of the idea of pressure. They look at situations where high pressure or low pressure is desirable.

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Ideas for the lesson

- Students may have forgotten the basic idea of a force (previously studied in Stage **7** Unit 9 Forces and motion). You could start this topic by revising the idea of force and how we represent forces as arrows. Revise also the unit of force (the newton, N).
- Students are familiar with nails and needles. These have sharp points in order to concentrate the applied force on a small area, so that they are more likely to penetrate the surface. Explain that pressure is a measure of how concentrated a force is.
- Discuss situations where we want high pressure, and where we want low pressure. (Some examples are given in the Coursebook.)
- Activity 9.4, Cricket stumps, invites students to think about the importance of maximising pressure at the pointed end of the stump, if it is to penetrate the soil. You could extend this activity by asking students to consider other situations – for example, gardening and farming tools, items of sports equipment, such as javelins.
- Workbook exercise 9.4, High pressure, low pressure, requires students to think of some other situations where pressure plays a significant role.

Common misunderstandings and misconceptions

Because students have recently studied density, they may confuse pressure and density, particularly since each is a ratio. You may need to disentangle the ideas of mass and force, as well as volume and area.

Homework ideas

- Workbook exercise 9.4, High pressure, low pressure
- Worksheet 9.5, Changing pressure

Topic 9.5 Pressure calculations

In this topic, students learn about pressure as a quantity and use the defining equation to calculate pressure and force.

Ideas for the lesson

- From the previous topic, it should be clear that pressure is related to force and area. By talking about force spread over a large area, students should come to understand that pressure is defined as force per unit area. (Technically, it might be better to call this 'stress', and reserve the term 'pressure' for gases and liquids. However, this refinement is not required by the course framework.)
- Discuss the units of pressure. Students will find it easier to think in terms of N / m^2 or N / cm^2, although they should also know the term Pascal (Pa) which is the same as N / m^2. You could discuss the importance of having an internationally agreed system of units for science, commerce etc. You could also discuss how units are derived from one another.
- Students may have come across other units of pressure, particularly in relation to atmospheric pressure, which may be given in hectopascal, bar, mbar, atmospheres, millimetres of mercury or torr. Car tyre pressure gauges may show more than one unit. You could discuss these in terms of some being more closely related than others to SI units.
- Worksheet 9.5, Changing pressure, requires students to think about how to create the greatest and least pressures, using two blocks.
- Activity 9.5, Squashing foam, is intended to give students a chance to make measurements and then calculate pressure. They could apply pressures to different samples of foam – do they all compress to the same extent?
- Students should be able to use the equation for pressure to calculate pressure or force. It is hard to think of any realistic situations where both pressure and force might be known but not the area concerned.

Common misunderstandings and misconceptions

- As with the equation for density, students should learn to rearrange the equation for pressure, rather than memorising two or three versions. It will help them if they think in terms of the units involved. In particular, $N / m^2 \times m^2 = N$ (the m^2 terms cancel), so force = pressure × area.

Homework ideas

- Workbook exercise 9.5, Calculations involving pressure
- Coursebook questions 1–3

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Topic 9.6 Pressure in gases and liquids

This topic considers the pressure exerted by a gas or liquid (fluid) in two ways: firstly, as being due to the weight of fluid pressing down from above, and secondly as arising from the collisions of particles with the surface of their container.

Ideas for the lesson

- You could start by blowing up a toy balloon. Students will know that this can be quite difficult, at least at first. You must blow with sufficient pressure to overcome the pressure exerted by the rubber material of the balloon. When the balloon is inflated, squeezing it gives an indication of the pressure of the air inside it.
- Discuss situations where pressure of a gas is important – pressure differences are what push a gas from one place to another.
- Similarly, pressure in a liquid is important. You could show images of submarines designed to go to great depths in the sea. They have thick walls and have curved shapes for strength to resist the great pressures experienced at depth. Where does this pressure come from? It comes from the weight of the water above, pressing down. (The pressure also acts sideways and upwards.)
- Discuss how the pressure in water increases with depth. The deeper you go, the greater the weight of water above you. Atmospheric pressure arises in the same way, from the weight of air above us, pressing down. Discuss the experience of climbers who may take oxygen supplies with them as they climb high mountains. (Everest, at nearly 9 km high, can be thought of as poking its summit out of the top of the atmosphere.)
- These ideas will be useful at a later stage when developing the equation for pressure in a fluid (= depth × density × g).
- Go on to discuss the nature of pressure on the microscopic scale, using the particle model of matter. Revise the nature of a gas by asking the question 'How do its particles move?'. Point out that it requires vast numbers of particle collisions each second to create the pressure of a gas.
- Activity 9.6, Pressure and particles, asks students to think about how changing the amount of gas and its volume would change the pressure it exerts. They should report their ideas to the class.
- Workbook exercise 9.6, Gas pressure, requires students to use particle ideas to explain aspects of the pressure of a gas.
- You could finish by demonstrating what happens when the pressure inside a balloon is greater than the rubber can withstand. The pressure required is a fraction of an atmosphere – car tyres are designed to withstand several atmospheres.

Common misunderstandings and misconceptions

- Students are relatively happy to accept that water has weight and thus exerts pressure at depth. They find it harder to accept that air has weight and that this is what causes atmospheric pressure. You could try to give students the idea that we are living at the bottom of a 'sea' of atmosphere.

Homework ideas

- Workbook exercise 9.6, Gas pressure

Topic 9.7 The turning effect of a force

This topic considers how a force can cause an object to turn. A force, acting at a distance from a pivot, has a turning effect. This topic considers this in broad terms and leads towards the development of the mathematical notion of moment of a force.

Ideas for the lesson

- You could start by revising ideas of forces. A force can be represented by an arrow; this is because it has both magnitude (size) and direction. The point at which a force acts can be moved and its effect may change as a consequence.
- Discuss situations where a force acts to cause something to turn. A door and its handle are the examples used in the Coursebook. Levers are further examples, but we do not go as far as to discuss levers and their three classes in Stage **9**.

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- Asking, 'Why is the door handle at the opposite edge of the door to the hinges?' may seem like a foolish question but it is important to understand why this is. We would find it hard to open a door if the handle were near the hinges. This should open up the issue of the size of the force and the distance from the pivot.
- Notice that, in this topic and the two that follow, we assume that the distance between the pivot and the force is the *perpendicular* distance. We will not worry about explaining the 'line of action' of the force, although you could demonstrate that a force has its greatest turning effect when it is perpendicular to the line joining the force and the pivot. Try lifting one end of a heavy wooden beam using a rope at different angles to the vertical.
- Activity 9.7, Scale maker, is intended to help students build up an intuitive understanding of how forces can be balanced by adjusting their positions relative to the pivot. Students may be able to adjust their scales to make it possible to weigh a range of items.
- Students will have to think carefully about how they make measurements, using their scales. In particular, they will have to measure distances from the pivot to the midpoint of the object they are weighing.
- You may need to remind students that a mass of 100 g has a weight of about 1.0 N.

Common misunderstandings and misconceptions

- You can help students to understand the turning effects of forces by drawing plan-view diagrams. Always represent forces by straight arrows. If you want to show the turning effect, use a curved arrow of a different colour.

Homework ideas

- Students could make their own weighing scales at home and demonstrate them to the class. You could test the weighing scales using known weights.

Topic 9.8 The principle of moments

This topic develops the idea of balancing further. It introduces the moment of a force as the quantity that measures the turning effect. It goes on to deal with the principle of moments.

Ideas for the lesson

- You could start by discussing what it is like to play on a seesaw (also known as a teeter-totter). How can you make it balance? How can you make it tip one way or the other? How can two children balance one child on the other end? Draw out the important quantities – the downward forces and their distances from the pivot.
- A seesaw is a helpful model because it is pivoted at its midpoint, so we can ignore its weight (which is evenly distributed between the two sides). Equally, we can ignore the upward force, which acts at the pivot.
- Introduce the idea that a force's turning effect can act in a clockwise or anticlockwise sense.
- Define the quantity 'moment of a force' as the product of force and distance. Ensure that students understand the distance that is meant here – the distance from the force to the pivot. (Topic 9.9 includes calculations involving moments.)
- Activity 9.8, Balancing a beam, will help students to appreciate that moments are equal and opposite when a beam is balanced. This activity is supported by Worksheet 9.8, Beam balancer; this includes a table for results, which suggests some suitable values of forces and distances for initial measurements.
- Complete the lesson by drawing out the principle of moments i.e. a beam is balanced when the clockwise moment acting on it is equal to the anticlockwise moment. Note that we are only considering situations where there is a single force acting on either side of the pivot. If there are two forces both acting clockwise, we must calculate the moment of each and add them together; do not add the forces and multiply by the combined distance.

Common misunderstandings and misconceptions

- Some students will have difficulty in imagining the direction (clockwise or anticlockwise) in which a force will cause an object to turn, particularly if the object is stationary or turning in the opposite direction.

Homework ideas

- Workbook exercise 9.8, Moments of forces

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Topic 9.9 Calculating moments

This topic completes our consideration of the turning effect of a force. It involves calculations to find an unknown force or distance for a balanced beam.

Ideas for the lesson

- Start by checking that students understand the principle of moments: clockwise moment = anticlockwise moment for a balanced beam.
- You could show an unbalanced beam with a load on either side. Ask the class to suggest four ways in which it could be balanced. (Move one load towards pivot, the other load away from the pivot; increase one load, decrease the other.) Moving the pivot is not allowed!
- From this, explain that there are four quantities involved in balancing a beam. If a beam is balanced, we can find an unknown quantity if the other three are known.
- The Coursebook includes examples where one distance is unknown and where one force is unknown. Check that students know how to substitute in the equation, rearrange it, and calculate the unknown quantity.
- Activity 9.9, Moment challenge, asks the students to devise two problems involving the principle of moments. The challenge is to exchange problems with a partner and get all the answers right. Students may find it easier to draw a diagram of the problem than to write it out in words.
- Workbook exercise 9.9, Balancing moments, provides more practice.

Common misunderstandings and misconceptions

- As before, check that students can identify clockwise and anticlockwise turning effects.

Homework ideas

- Students could make their own weighing scales at home and demonstrate them to the class. You could test the weighing scales, using known weights.
- Coursebook questions 1–3

End of unit questions

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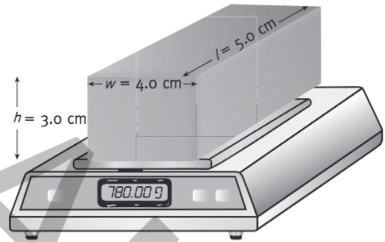
Worksheet 9.2 Density techniques

Here are two techniques used for finding the densities of different materials. One is a solid, the other a liquid.

Density of a solid

The block shown is made of polystyrene foam (Styrofoam).



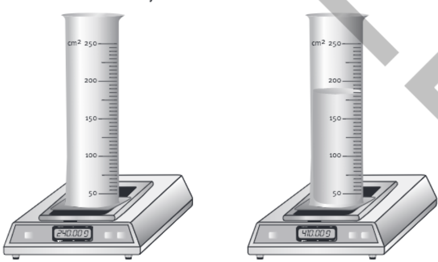
1 Complete the table to find the density of the foam.

2 Measure two other blocks. Put your results in the remaining columns and find the densities.

Material	Polystyrene foam		
width (w) in cm			
height (h) in cm			
length (l) in cm			
volume ($V = w \times h \times l$) in cm^3			
mass (m) in g			
density (m/V) in g/cm^3			

Density of a liquid

The picture shows how to find the density of water.



3 Complete the table to find the density of the liquid.

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4 Measure two other volumes of water. Put your results in the remaining columns and find the densities.

Material	**Water**		
mass of empty measuring cylinder (m_1) in g			
mass of measuring cylinder with liquid (m_2) in g			
mass of liquid (m) in g			
volume of liquid (V) in cm^3			
density (m/V) in g/cm^3			

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Worksheet 9.3 Density calculations

Your task is to think up two problems for your partner to solve. One must involve calculating mass, the other volume.

The table shows the densities of some important materials. Choose data from the table to use in your problems.

Material	Density in g/cm^3
water	1.0
copper	8.9
gold	19.3
lead	11.3
ice	0.92
wood (oak)	0.65
brick	2.3
air	0.0013

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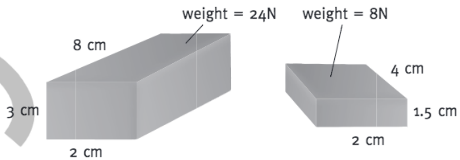
Worksheet 9.5 Changing pressure

When a rectangular block lies on the floor, it causes pressure on the floor. You can change the pressure by changing the way the block lies on the floor.

The picture shows two blocks.



1 Look at the block on the left. How would you place the block so that it gives the maximum pressure on the floor? Draw a picture and calculate the pressure.

Explain why you have chosen to show the block like this.

....

....

2 Think again about this block. How would you place the block so that it gives the minimum pressure on the floor? Draw a picture and calculate the pressure.

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Explain why you have chosen to show the block like this.

....

....

3 Now think about both blocks together. How would you place the blocks to give the maximum pressure on the floor? Draw a picture and calculate the pressure.

Explain why you have chosen to show the blocks like this.

....

....

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Worksheet 9.8 Beam balancer

1 Set up the beam as shown. Your task is to alter the weights and their positions and to find the rule that decides if the beam is balanced.

2 Start with a 1 N weight placed 20 cm from the pivot. Place a 2 N weight on the other side of the pivot so as to balance the beam. You should find that it must be placed 10 cm from the pivot.

The table shows how to record this result.

The moment of each force is calculated by multiplying the force (columns 1 and 4) by its distance from the pivot (columns 2 and 5); the answers are written in columns 3 and 6.

Force on left of pivot			Force on right of pivot		
1	2	3	4	5	6
Force / N	Distance from pivot / cm	Moment of force / N cm	Force / N	Distance from pivot / cm	Moment of force / N cm
1	20	20	2	10	20
1	30		2		
3	20		4		

3 Copy the table. Complete the second and third rows by finding where the weights must be placed to balance the beam.

4 Complete the remaining rows by choosing weights and finding how to balance them.

Each time, calculate the moment of each force.

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Mary Jones, Diane Fellowes-Freeman and David Sang

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