ENGLISH IN FOCUS

English in Workshop Practice

ALAN MOUNTFORD
Contents

Introduction xi

Unit 1 Calipers 1

I: READING AND COMPREHENSION 1
SOLUTIONS TO COMPREHENSION PROBLEMS 2
EXERCISE A: Contextual reference 3
EXERCISE B: Rephrasing 4
EXERCISE C: Relationships between statements 4
EXERCISE D: Labelling of diagrams 5
EXERCISE E: The definition of objects in terms of class and use 5
EXERCISE F: General statements 8

II: GRAMMAR 9
EXERCISE A: Forms of definitions 9
EXERCISE B: The use of nouns and adjectives in definitions (Shapes) 10
EXERCISE C: The use of nouns and adjectives in general statements (Dimensions) 11

Unit 2 The micrometer 14

I. READING AND COMPREHENSION 14
SOLUTIONS TO COMPREHENSION PROBLEMS 15
EXERCISE A: Contextual reference 16
EXERCISE B: Rephrasing 16
EXERCISE C: Labelling a diagram 17
EXERCISE D: Description of a micrometer through the selection of words from alternatives 17
## Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Exercise</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>EXERCISE E:</strong></td>
<td>Description of objects in terms of their main parts and construction</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE F:</strong></td>
<td>Re-ordering of sentences to build descriptive paragraphs</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE G:</strong></td>
<td>Definitions plus descriptions of objects</td>
<td>21</td>
</tr>
<tr>
<td><strong>II: GRAMMAR</strong></td>
<td></td>
<td>The passive</td>
<td>23</td>
</tr>
<tr>
<td><strong>Unit 3</strong></td>
<td><strong>Bench work</strong></td>
<td></td>
<td>27</td>
</tr>
<tr>
<td><strong>I:</strong></td>
<td><strong>READING AND COMPREHENSION</strong></td>
<td></td>
<td>27</td>
</tr>
<tr>
<td></td>
<td><strong>SOLUTIONS TO COMPREHENSION PROBLEMS</strong></td>
<td></td>
<td>28</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>Contextual reference</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>Rephrasing</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE C:</strong></td>
<td>Relationships between statements</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE D:</strong></td>
<td>Definitions of operations</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE E:</strong></td>
<td>Generalizations</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE F:</strong></td>
<td>Writing descriptions from information in a table</td>
<td>35</td>
</tr>
<tr>
<td><strong>II:</strong></td>
<td><strong>GRAMMAR</strong></td>
<td></td>
<td>36</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>The use of to + infinitive in the expression of purpose</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>The use of in order to + infinitive and so as to + infinitive in the expression of purpose</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE C:</strong></td>
<td>The statement of purpose in the first part of a sentence</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE D:</strong></td>
<td>The use of so that + clause in the expression of result and purpose</td>
<td>39</td>
</tr>
<tr>
<td><strong>Unit 4</strong></td>
<td><strong>Metals and their properties</strong></td>
<td></td>
<td>41</td>
</tr>
<tr>
<td><strong>I:</strong></td>
<td><strong>READING AND COMPREHENSION</strong></td>
<td></td>
<td>41</td>
</tr>
<tr>
<td></td>
<td><strong>SOLUTIONS TO COMPREHENSION PROBLEMS</strong></td>
<td></td>
<td>42</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>Contextual reference</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>Rephrasing</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE C:</strong></td>
<td>Relationships between statements</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE D:</strong></td>
<td>Classification and levels of generalization</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE E:</strong></td>
<td>Classification according to defining characteristics</td>
<td>48</td>
</tr>
<tr>
<td><strong>II:</strong></td>
<td><strong>GRAMMAR</strong></td>
<td></td>
<td>51</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>Defining and non-defining relative clauses</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>Short-form relative clauses</td>
<td>53</td>
</tr>
<tr>
<td><strong>Unit 5</strong></td>
<td><strong>The forge</strong></td>
<td></td>
<td>56</td>
</tr>
<tr>
<td><strong>I:</strong></td>
<td><strong>READING AND COMPREHENSION</strong></td>
<td></td>
<td>56</td>
</tr>
<tr>
<td></td>
<td><strong>SOLUTIONS TO COMPREHENSION PROBLEMS</strong></td>
<td></td>
<td>57</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>Contextual reference</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>Rephrasing</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE C:</strong></td>
<td>Relationships between statements</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE D:</strong></td>
<td>Restatements</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE E:</strong></td>
<td>Labelling of diagrams</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE F:</strong></td>
<td>Inductions, deductions and predictions: the properties of metals</td>
<td>62</td>
</tr>
<tr>
<td><strong>II:</strong></td>
<td><strong>GRAMMAR</strong></td>
<td></td>
<td>66</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>Relative clauses introduced by a preposition</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>Noun + noun constructions</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE C:</strong></td>
<td>Participle + noun constructions</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE D:</strong></td>
<td>Complex noun phrases</td>
<td>69</td>
</tr>
<tr>
<td><strong>Unit 6</strong></td>
<td><strong>Heat treatment</strong></td>
<td></td>
<td>71</td>
</tr>
<tr>
<td><strong>I:</strong></td>
<td><strong>READING AND COMPREHENSION</strong></td>
<td></td>
<td>71</td>
</tr>
<tr>
<td></td>
<td><strong>SOLUTIONS TO COMPREHENSION PROBLEMS</strong></td>
<td></td>
<td>72</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>Contextual reference</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>Rephrasing</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE C:</strong></td>
<td>Relationships between statements</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE D:</strong></td>
<td>Description of an operation and its result</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE E:</strong></td>
<td>Instructions based on descriptions</td>
<td>78</td>
</tr>
<tr>
<td><strong>II:</strong></td>
<td><strong>GRAMMAR</strong></td>
<td></td>
<td>80</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>Time expressions: after, before, when, as soon as, while, until</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>Time expressions: then, during, throughout, prior to, first</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE C:</strong></td>
<td>Short-form time clauses</td>
<td>82</td>
</tr>
<tr>
<td><strong>Unit 7</strong></td>
<td><strong>Sheet metal work</strong></td>
<td></td>
<td>83</td>
</tr>
<tr>
<td><strong>I:</strong></td>
<td><strong>READING AND COMPREHENSION</strong></td>
<td></td>
<td>83</td>
</tr>
<tr>
<td></td>
<td><strong>SOLUTIONS TO COMPREHENSION PROBLEMS</strong></td>
<td></td>
<td>84</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE A:</strong></td>
<td>Contextual reference</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE B:</strong></td>
<td>Rephrasing</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE C:</strong></td>
<td>Relationships between statements</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE D:</strong></td>
<td>Restatements using expressions of time</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE E:</strong></td>
<td>Extracting information from the reading text</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE F:</strong></td>
<td>Writing instructions for illustrations</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td><strong>EXERCISE G:</strong></td>
<td>Writing recommendations and rules</td>
<td>90</td>
</tr>
<tr>
<td><strong>II:</strong></td>
<td><strong>GRAMMAR:</strong></td>
<td>Modal verbs</td>
<td>94</td>
</tr>
<tr>
<td>Unit 8</td>
<td>Reading passages with comprehension questions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASSAGE I: Soldering</td>
<td>97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASSAGE II: Welding</td>
<td>99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASSAGE III: Marking out</td>
<td>101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASSAGE IV: The drilling machine</td>
<td>104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FURTHER COMPREHENSION EXERCISES</td>
<td>107</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructions, descriptions and reports</td>
<td>107</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4 Metals and their properties

I READING AND COMPREHENSION

1 We may distinguish two groups of metals. 2 Those which contain mainly iron are called ferrous metals, and those in which the basic material is a metal other than iron are termed non-ferrous metals. 3 The former include cast iron, wrought iron, and steel. 4 Copper, tin, zinc, and lead are examples of non-ferrous metals. 5 When some metals are combined, they form an alloy. 6 Non-ferrous alloys include brass, which is made from copper and zinc, and bronze, which is made from copper and tin.

(a) The basic material of ferrous metals is iron.
(b) Metals can be combined to form an alloy.
(c) Examples of non-ferrous alloys are brass and bronze.

7 Cast iron is really an alloy of iron and carbon. 8 It is made from pig iron which has been remelted and made purer. 9 Cast iron is, then, refined pig iron. 10 The amount of carbon in cast iron is reduced to between 2½ and 4 per cent. 11 As cast iron is very brittle, it will not bend. 12 It cannot be forged, either. 13 On the other hand, it is easily shaped by casting and some types can be easily machined. 14 Cast iron is used for making surface plates, vee blocks and marking-out tables.

(d) Cast iron can be neither forged nor bent.
(e) The carbon content of cast iron is 2½–4%.
(f) Cast iron is made from pig iron which has been refined.

15 Steel is basically an iron-carbon alloy, too. 16 It is made by reducing the carbon content of pig iron to amounts which are exactly known. 17 It can also be made by adding known amounts of carbon to almost pure iron. 18 If only carbon is added, plain carbon steels are produced. 19 If other elements are added, alloy steels are produced. 20 Stainless steel contains both nickel and chromium, and the main element added to make most types of high speed steel is tungsten.
There is nickel and chromium in stainless steel.

Alloy steels contain elements in addition to iron and carbon.

Plain carbon steels may be classified according to their carbon content.
Low carbon, or mild, steel has up to 0.25% carbon in it.
It is easily cut, filed and drilled, and it can be forged.
Medium carbon steel contains between 0.25 and 0.5% carbon.
Dark and stronger than mild steel, it is used for things which have to be tough.
High carbon steel has a carbon content of 0.5 to 1.3%.
It is a dark steel and it is very strong.
It is used for making files, centre punches and hacksaw blades.
It is known as tool steel.

Mild steel has up to 0.25% carbon in it.
Tool steel has up to 1.3% carbon in it.
Medium carbon steel has a carbon content of between 0.25 and 0.5%.
Mild steel contains more than 0.25% carbon.

Solutions

Those (i.e. groups of metals) which contain mainly iron are called ferrous metals

Ferrous metals contain mainly iron

which contain mainly iron = of which the basic material is iron

those (i.e. groups of metals) in which the basic material is a metal other than iron are termed non-ferrous metals

a metal other than iron = a metal which is not iron

The basic material of ferrous metals is iron.

When some metals are combined, they form an alloy

Some metals can be combined to form an alloy (see Unit 3, Grammar)

Some metals i.e. not all metals

But metals can be combined to form an alloy = All metals can be combined to form an alloy.

It is not true to say that metals (i.e. all metals) can be combined to form an alloy.

Non-ferrous alloys include brass...and bronze.

Brass and bronze are examples of non-ferrous alloys.

Examples of non-ferrous alloys are brass and bronze.

(Cast iron) will not bend (11). It cannot be forged, either.

Cast iron cannot be bent and it cannot be forged.

Cast iron cannot be forged nor bent.

The amount of carbon in cast iron is reduced to between 2.5 and 4 per cent.

The amount of carbon in cast iron is between 2.5 and 4 per cent.

The amount of carbon in cast iron = the carbon content of cast iron

The carbon content of cast iron is 2.5-4%.

It (i.e. cast iron) is made from pig iron which has been remelted and made purer.

Cast iron is, therefore, refined pig iron.

Remelted and made purer = refined pig iron = pig iron which has been refined.

Cast iron is made from pig iron which has been refined.

[X Stainless steel] [Y contains] both [Z nickel and chromium].

[Y There is] [Z nickel and chromium] [X in stainless steel].

There is nickel and chromium in stainless steel.

If only carbon is added (to pig iron (16)) plain carbon steels are produced.

If other elements are added, alloy steels are produced.

Alloy steels are produced if other elements are added.

Alloy steels are produced if other elements are added to iron and carbon.

Other elements are added to iron and carbon = there are elements in addition to iron and carbon.

Alloy steels contain elements in addition to iron and carbon.

Low carbon, or mild, steel has up to 0.25% carbon in it.

Low carbon steel is also called mild steel.

Mild steel has up to 0.25% carbon in it.

High carbon steel has a carbon content of 0.5 to 1.3%.

High carbon steel is known as tool steel.

Tool steel has a carbon content of 0.5 to 1.3%.

Tool steel has up to 1.3%.

Medium carbon steel contains between 0.25 and 0.5% carbon.

Medium carbon steel has a carbon content of between 0.25 and 0.5%.

Low carbon, or mild, steel has up to 0.25% carbon in it.

Mild steel has no more than 0.25% carbon in it.

Mild steel does not contain more than 0.25% carbon.
EXERCISE A Contextual reference

1. In sentence 2, *those* refers to:
   (a) groups of metals
   (b) ferrous metals
2. In sentence 3, *the former* refers to:
   (a) non-ferrous metals
   (b) ferrous metals
   (c) groups of metals
3. In sentence 5, *they* refers to:
   (a) some metals
   (b) non-ferrous metals
   (c) copper, tin and zinc
4. In sentence 23, *it* refers to:
   (a) plain carbon steel
   (b) low carbon steel
   (c) mild steel
5. In sentence 25, *it* refers to:
   (a) medium carbon steel
   (b) mild steel
6. In sentence 29 *it* refers to:
   (a) mild steel
   (b) high carbon steel
   (c) medium carbon steel.

EXERCISE B Rephrasing

Rewrite the following, using words and constructions from the text to replace those printed in italics.

1. The *main element* of ferrous metals is iron.
2. Non-ferrous metals which are combined include brass and bronze.
3. Cast iron is made from pig iron which has been *re-melted* and made purer.
4. Cast iron breaks easily.
5. Cast iron can be easily given a shape by pouring the molten metal into a mould.
6. Steel can be made by adding *certain amounts* of carbon which are exactly known to almost pure iron.
7. Plain carbon steels may be divided up into groups on the basis of their carbon content.

EXERCISE C Relationships between statements

Place the following expressions in the sentences indicated. Replace and re-order the words in the sentence where necessary.

(a) *namely... namely*  
(b) whereas  
(c) *for example*  
(d) in other words  
(e) *so*  
(f) nor  
(g) *however*  
(h) therefore  
(i) *alternatively*  
(j) *however*  
(k) *for example*  
(l) *consequently*  
(m) *and for this reason*  
(n)  
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(14)  
(15)  
(16)  
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(18)  
(19)  
(20)  
(21)  
(22)  
(23)  
(24)  
(25)  
(26)  
(27)  
(28)  
(29)  

EXERCISE D Classification and levels of generalization

Part 1

Draw the following diagram and fill in the blank spaces, using information contained in the texts.

The diagram is a *classification* of metals. There are 4 levels of generalization. Items at a higher level are more general than items at a lower level. Items at a lower level belong to *classes* of items which are at a higher level. We may add a fifth level which represents *examples* of the classes of metals at the third and fourth levels.

Part 2

Arrange the following examples of metals in their correct classes, labelled A, B, C, D, E in the diagram above. For example, (a) *mild steel* is A (i.e. a kind of plain carbon steel).

(a) *mild steel*  
(b) copper  
(c) high speed steel  
(d) cast iron  
(e) aluminium  
(f) wrought iron  
(g) zinc  
(h) bronze  
(i) stainless steel  
(j) lead  
(k) medium carbon steel  
(l) tool steel  
(m) brass  
(n) tin  
(o) silver steel

Part 3

Write as many simple definitions as possible of the metals in the list in Part 2, above.

First, study the following examples carefully.
EXERCISES
Mild steel is a plain carbon steel.
Mild steel is a ferrous metal.
Mild steel belongs to a class of metals called plain carbon steels.
Mild steel may be classed as a plain carbon steel.

PART 4
Classify the following items in the form of diagrams as in Part 1 above.
(a) workshop materials — metallic — non-metallic — ferrous — non-ferrous —
wood — plastics — iron — steel — tin — copper.
(b) hand tools — cutting — hitting — single cutting edge — multiple cutting
edges — hammers — mallets — chisels — scrapers — files — hacksaws.
(c) metal joining methods — soldering — welding — riveting — soft soldering —
silver soldering — brazing — oxy-acetylene — electric arc.
(d) engineer's instruments — measuring — marking out — steel rule — micrometer — vernier calipers — scriber — dividers.
(e) plain carbon steels — low carbon steels — black mild steel — bright drawn
mild steel — medium carbon steels — high carbon steels — tool steel — silver
steel.
(f) pig iron — wrought iron — cast iron — grey iron — white iron — malleable
cast iron.
(g) weight unit — metric unit — non-metric unit — kilogram — gram — pound —
ounce — ton — stone.
(h) measuring unit — metric unit — non-metric unit — kilometre — metre —
centimetre — millimetre — yard — mile — foot — inch.
(i) timber — hardwoods — softwoods — oak — beech — mahogany — white
wood — red wood — spruce — pitch pine.

PART 5
Study the following tables carefully.

| (a) | can be divided into two classes; | ferrous and non-ferrous. |
| Metals | groups; kinds: | |
| may be divided into classified as |

| (b) | Two | can be distinguished: ferrous and non-ferrous. |
| groups | of metal | |
| classes | kinds | may be |

1. Write down and complete the following paragraph using the information
from the diagram in Parts 1 and 2 above.

Note that many of the sentences are similar in construction to those in the
tables given above.
Metals can be classified as ... and ... The former may be divided into
steels and ... while non-ferrous metals may be divided into ... such as ...
and ... and non-alloys, or pure metals, such as ... and ... and ...
Two kinds of steel may be distinguished: ... steels and ... steels. Examples of
the former include ... steel and ... steel. ... steel and ... steel are
examples of alloy steel.

2. Using the patterns given in the tables above, write out classifications of
the items which you have arranged in diagrams in Part 4.

EXAMPLES
(i) Workshop materials can be divided into two main classes: metallic
and non-metallic. There are two types of metallic material, ferrous
and non-ferrous. Non-metallic materials include wood and plastics.
Examples of ferrous metals are iron and steel. Non-ferrous materials
include metals such as tin and copper.

OR (ii) Workshop materials may be classified as metallic and non-metallic.
Two kinds of metallic material can be distinguished: ferrous metals,
such as iron and steel, and non-ferrous — such as tin and copper.
Non-metallic materials include wood and plastics.

PART 6
A statement which uses a higher level item is more general than a statement
which uses lower level items. In the following statements (i) is more general
than (ii), (ii) is more general than (iii), and (iii) is more general than (iv).

(i) Tools are made from steel.
(ii) Hand tools are made from steel.
(iii) A file is made from steel.
(iv) A round file is made from steel.

Note that if (i) is true, then (ii), (iii) and (iv) are also true.

1. Change the following statements into higher level generalizations. In
brackets are the exercises in Part 4 above and the levels of generalization
by reference to which you should rewrite the statement. In order to do
this, refer to the classifications which you made in Part 4. Make any other
changes in the sentences which are necessary.
EXAMPLE

A flat file is made from high carbon steel. [b, level 3]

Hand tools with multiple cutting edges are made from high carbon steel.

(a) Hand tools are usually made from hardened tool steel. [e, level 2]
(b) Diamond-point chisels are used for removing metal and should be kept sharp. [b, level 2]
(c) The basic materials in malleable cast iron are iron and carbon. [f, level 1]
(d) Copper expands when it is heated. [a, level 2]
(e) A scriber should be kept free from rust and dust. [d, level 1]
(f) Odd-leg calipers are made from tool steel. [d, level 2]
(g) Oxy-acetylene welding can be dangerous, and requires a great deal of skill and practice. [e, level 1]

2. Use the statements in 1 above and the generalizations you have made from them to make statements of the following kind.

EXAMPLE

Tools are made from tool steel.
A flat file is a tool.
Therefore (‘.’) a flat file is made from tool steel.

EXERCISE E Classification according to defining characteristics

Classifications are made according to some principle of classification, and statements are made in the active or passive form.

EXAMPLES

(i) (a) We may classify files according to their shape.
(b) Files may be classified according to their shape.

(ii) (a) We may classify hacksaw blades according to the number of teeth per inch.
(b) Hacksaw blades may be classified according to the number of teeth per inch.

Such statements may be followed by examples of particular objects and a statement of their defining characteristics.

EXAMPLE

<table>
<thead>
<tr>
<th>Object</th>
<th>Principle of Classification</th>
<th>Examples</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Files</td>
<td>shape</td>
<td>round files</td>
<td>round cross-sectional shape</td>
</tr>
<tr>
<td></td>
<td>square files</td>
<td></td>
<td>square cross-sectional shape</td>
</tr>
</tbody>
</table>

Files may be classified according to their shape. For example, round files have a round cross-sectional shape but square files have a square cross-sectional shape.

Part 1

Make statements about how the following objects may be classified as in the example:

<table>
<thead>
<tr>
<th>Object</th>
<th>Principle of Classification</th>
<th>Examples</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) hacksaw blades</td>
<td>number of teeth per inch (t. p. i.)</td>
<td>fine blades</td>
<td>20 to 30 t. p. i.</td>
</tr>
<tr>
<td></td>
<td>coarse blades</td>
<td></td>
<td>14 to 18 t. p. i.</td>
</tr>
<tr>
<td>(b) scrapers</td>
<td>shape of the blade</td>
<td>flat scrapers</td>
<td>flat blade</td>
</tr>
<tr>
<td></td>
<td>half-round scrapers</td>
<td></td>
<td>curved blade</td>
</tr>
<tr>
<td>(c) hammers</td>
<td>shape</td>
<td>ball-pein hammers</td>
<td>round peins and a flat striking face.</td>
</tr>
<tr>
<td></td>
<td>cross-pein hammers</td>
<td></td>
<td>chisel-shaped peins and a flat striking face.</td>
</tr>
<tr>
<td>(d) chisels</td>
<td>type of cutting edge</td>
<td>flat chisels</td>
<td>a flat cutting edge</td>
</tr>
<tr>
<td></td>
<td>diamond-pointed chisels</td>
<td></td>
<td>a sharply tapered point</td>
</tr>
<tr>
<td>(e) plain carbon steels</td>
<td>carbon content</td>
<td>mild steel</td>
<td>less than 0.25% carbon</td>
</tr>
<tr>
<td></td>
<td>tool steel</td>
<td></td>
<td>up to 1.3% carbon</td>
</tr>
<tr>
<td>(f) Files</td>
<td>type of cut</td>
<td>single-cut files</td>
<td>cuts in one direction only</td>
</tr>
<tr>
<td></td>
<td>double cut files</td>
<td></td>
<td>cuts in two directions forming a diamond pattern</td>
</tr>
</tbody>
</table>

Part 2

Note that the order C + A + D in the exercises above produce a definition of the particular example. It is defined according to its appearance.

EXAMPLE

[C A round file] is [A a file] which has a [D round cross-sectional shape].

Define the following, using the information given in Part 1 above.

(a) a square file (f) a diamond-point chisel
(b) a flat scraper (g) mild steel
(c) a half-round scraper (h) tool steel
(d) a ball-pein hammer (i) a double-cut file
(e) a flat chisel (j) a single-cut file.
Part 3
There is another way of stating a principle of classification followed by examples. Study the following pattern:

[A Metals] may be classified according to whether they [B contain iron or not].

For example, C1 in ferrous metals D1 iron is the main constituent
C2 in non-ferrous metals D2 there is little or no iron

The pattern can be stated as follows:
A may be classified according to whether they B.
For example, C1 + D1, whereas C2 + D2.

We can now read the pattern as follows:
Metals may be classified according to whether they contain iron or not.
For example, in ferrous metals iron is the main constituent, whereas in non-ferrous metals there is little or no iron.

Now write out similar statements from the material in (a) and (b) below.

(a) A Ferrous metals B carbon is deliberately added or not
C1 in steel D1 carbon is added to strengthen the material
C2 in cast iron D2 excess carbon is an impurity and must be reduced

(b) A Metal joining methods B heat is used or not
C1 in welding D1 metals are joined together by fusion
C2 in riveting D2 metals are joined together mechanically using rivets

The pattern in (c)–(f) below is more complicated. First, look carefully at the material in (c).

(c) A Steels B carbon is the only element added or other elements are added
C1 plain carbon steel D1 is made by adding known amounts of carbon to almost pure iron
C2 alloy steels D2 are made by adding elements such as tungsten and chromium in addition to carbon

The pattern can be stated as follows:
A may be classified according to whether B1 or whether B2.
For example, C1 + D1, whereas C2 + D2.

We can now read (c) as follows:
Steels may be classified according to whether carbon is the only element added or whether other elements are added. For example, plain carbon steel is made by adding known amounts of carbon to almost pure iron, whereas alloy steels are made by adding elements such as tungsten and chromium in addition to carbon.

Now write out similar statements from the material in (d), (e) and (f).

(d) A Engineers’ instruments B they are used for measuring or they are used for marking out
C1 micrometers and vernier calipers D1 are used for measuring the dimensions of components
C2 scribers and dividers D2 are used for drawing lines on metal

(e) A Non-ferrous metals B the metal is in a pure state or it is alloyed to another non-ferrous metal
C1 copper D1 is a pure non-ferrous metal
C2 bronze D2 is an alloy of copper and tin

(f) A Hand tools B they have a single cutting edge or multiple cutting edges
C1 chisels D1 have only one cutting edge
C2 files D2 have many cutting edges from diagonal grooves which cross each other

II GRAMMAR

EXERCISE A Defining and non-defining relative clauses
Look at this table:

A metals
B + B metals = C metals

ferrous non-ferrous contain iron do not contain iron ferrous contain iron non-ferrous do not contain iron
Some metals are called ferrous metals. 
Some metals contain iron.

Metals which contain iron are called ferrous metals. 

Ferrous metals are metals which contain iron.

Some metals are called non-ferrous metals. 
Some metals do not contain iron.

Metals which do not contain iron are called non-ferrous metals. 

Non-ferrous metals are metals which do not contain iron.

Expressions in which the main word is a noun are called noun phrases.
If two sentences each contain a noun phrase, and the noun phrases each refer to the same thing, then the sentences can be joined together by a relative pronoun, as in the statements C above. In those statements the relative pronoun is which.

Now, compare the following sentences:
(i) A machine which is dangerous should be provided with a protective casing.
(ii) A drilling machine, which is dangerous, should be used with the drill guard down.

The first sentence is an example of a defining relative clause. The clause tells us what machine we are talking about: i.e. a machine which is dangerous. The second sentence is an example of a non-defining relative clause. In this case we know what machine we are talking about: i.e. a drilling machine. The relative clause simply tells us something more about the machine: i.e. . . . , a drilling machine is dangerous, . . . . Non-defining relative clauses are usually separated from the rest of the sentence by commas, or by brackets or by dashes.

Combine each pair of sentences into a single sentence. Change the second sentence into a relative clause and insert it into the first sentence at the point indicated by the dots. In each case say whether the relative clause is defining or non-defining.

1. A metal . . . . is malleable. A metal can be spread out by hammering without cracking.
2. Bending and pressing and hammering of a metal often leads to a condition . . . . The condition is known as work hardening.
3. Brass . . . . is a non-ferrous alloy. Brass is made from copper and zinc.
4. A fitter works on a heavy, rigid bench . . . . The bench has a vice bolted on it.
5. A surface grinder may be used for producing a finish on metal . . . . Metal has been cut on another machine.
6. The working head of a soldering iron is usually made of copper . . . . Copper is a good conductor of heat.
7. Some hacksaw blades are made from steel . . . . Steel has been hardened throughout.
8. A micrometer is an instrument . . . . The instrument is used for measuring small distances very precisely.
9. Oxygen and acetylene, when mixed together, can produce a flame . . . . The flame reaches a temperature of about 3300°C.
10. Low carbon steel . . . . contains up to 0.25% carbon. Low carbon steel is also known as mild steel.
11. The teeth of a hacksaw are set at angles so that the saw makes a cut . . . . The cut is wider than the blade.
12. There are two types of soldering iron: plain irons . . . . and electric irons . . . . Plain irons have to be heated on a gas ring. Electric irons have an internal element for heating.
13. A plain steel . . . . can be recognized by a stream of long white sparks . . . . A plain steel has a low carbon content. The sparks are produced when it is ground on an emery wheel.
14. Lead is a light grey metal . . . . The metal darkens quite rapidly when it is exposed to the atmosphere . . . . The atmosphere gives it a more familiar dark colour.
15. The properties of irons and steels depend on the amount of carbon . . . . Carbon has been added to them.
16. The cables . . . . are called conductors. They carry electric current to the various machines and tools in a factory.
17. A hacksaw consists of a frame . . . . and a blade . . . . The former may be adjustable. The latter is tensioned by a wing nut at one end of the frame.
18. The legs of spring calipers are opened or closed by means of a screw . . . . This screw is controlled by an adjusting nut.

EXERCISE B Short-form relative clauses
Part 1
Relative clauses often appear in a shortened form.
(i) In clauses which begin which has or which have, with may be used instead.

EXAMPLE

Steel which have a carbon content of between 0.5 and 1.3% are known as high carbon steels.

Steel with a carbon content of between 0.5 and 1.3% are known as high carbon steels.

(ii) In clauses in which the verb is active, the -ing form of the verb may be used instead.

EXAMPLES

Steel which have a carbon content of between 0.5 and 1.3% are known as high carbon steels.
Steel having a carbon content of between... steel.
Steel containing between 0.5 and 1.3% of carbon are known as high carbon steels.
Steel containing between 0.5 and 1.3%...

(iii) In clauses in which the verb is passive, the relative pronoun and the verb to be can be omitted.

EXAMPLES
High carbon steel, which is known as tool steel, usually has more than 1% carbon in it.
High carbon steel, known as tool steel...
Steel which is used for making files, centre punches and hacksaw blades has to be very strong.
Steel used for making files, centre punches...

Combine each of the following pairs of sentences into a single sentence. Change the second sentence into a short-form relative clause, using one of the ways shown above, and insert it into the first sentence at the point indicated by the dots. In each case state whether the resulting construction is defining or non-defining, as in the example.

EXAMPLE
The heat... is produced by an electric arc.
The heat is required for welding.
= The heat which is required for welding is produced by an electric arc.
(defining)
= The heat required for welding is produced by an electric arc.

1. The vice... must be at the correct height.
The vice holds the work on the fitter’s bench.
2. Typical objects... include springs, hammers, shafts and axles.
Objects are made from medium carbon steel.
3. Steel is essentially an iron-carbon alloy...
The alloy contains less than 1.7% carbon.
4. Wrought iron is made by remelting and refining pig iron in a small furnace...
The furnace is known as a puddling furnace.
5. Nickel steels are of two types: low nickel steels... and high nickel steels... The former have 3-5% nickel.
The latter have 25-40% nickel.
6. The main part of a micrometer is a semi-circular frame...
The frame has a barrel...
The barrel is attached to one end through which a spindle screws.
7. Usually in welding, the two materials... are of the same composition.
They are to be joined together.

8. A flexible steel tape, ..., rolls into a case.
   It has each inch or centimetre marked in uniform divisions.
9. A hammer consists of a head, ..., and a shaft, ...
   One is made of cast steel ... It has a hardened striking face.
The other is made from well-seasoned wood.
10. Bench stakes are used to support work and have many different shapes and sizes ...
    These shapes and sizes depend on the article ... and the process ...
    An article is being made.
A process is being carried out.

Part 2

Look at the sentences containing relative clauses which you wrote in Grammar Exercise A. Shorten the following sentences from that exercise in one of the ways shown above.
2, 3, 4, 5, 8, 9, 10, 13, 15, 16, 18.