| Codes and Ciphers | UNIT 1 <i>Substitution</i> <i>Ciphers</i> Lesson Plan 1 | Caesar Ciphers |
|-------------------------|--|--|
| Activity | | Notes |
| 1 | Introduction | T: Teacher P: Pupil Ex.B: Exercise Book |
| 1 | T: We're going to start by looking at a method for hiding messages used by the Romans. This is called a 'Caesar cipher'. Do you know why? (Named after the Roman Emperor Julius Caesar) | Class discuss the advanced civilisation that existed in Roman times. |
| | T: Here is an example. Our message to code is THIS CODE WAS INVENTED BY JULIUS CAESAR | T now reveals this sentence on board or OHP. |
| | Can you think of a quick and easy way to make this secret? (Move each letter forwards or backwards by one) T: Let's move or shift each letter on by three so that A → D | T considers suggestions that Ps make but emphasises that the <i>simplest</i> method is needed at this stage. |
| | $B \rightarrow ?$ (E) $C \rightarrow ?$ (F) $M \rightarrow ?$ (P) | Interactive; T asks around class; opportunity for quieter Ps to contribute. |
| | T: What can we do to speed up this process and make it easier? (<i>Make a list for the complete alphabet</i>) | |
| | OS 1.1 | List on OHP or use OS 1.1. |
| | T: That's right. Who would like to start this task on the board? Plain A B C P C P C P To Write the measure in code in course En D | Volunteer Ps complete the cipher grid on OS. All Ps complete the grid in their Ex.Bs or on a copy of OS 1.1 . |
| | Who would like to write their code on the board? | Volunteer P writes the message in code on board. Other Ps agree/disagree. |
| | 10 mins | Checking, agreement. Praising. |
| 2 | Practice: Exercise 1 | |
| | T: Now try Exercise 1 on the sheet. | Individual or paired work. T monitors, Ps work. After some minutes, T stops Ps working and reviews answers interactively |
| | T: Who has the solution? Please write it on the board. | Volunteer P writes solution on |
| | P (on board): GONE TO WATCH HARLEQUINS. BACK AT SEVEN. | board. Agreement, feedback, self- correction. Praising. |
| | 15 mins | |
| 3 | Extending the idea | |
| | T: How can we design a different Caesar cipher? (Shift by different amounts) | Ps suggest ideas; discuss shifting backwards and |
| | T: How many ways are there of doing this? (26 ways) | forwards; e.g. one back is the same as 25 forwards, etc. |
| | T: We can see all 26 ways in this grid called a Vigenere square. | OS 1.2 shown on OHP; Ps are |
| (continued) | This message is coded using one of the shifted alphabets in the Vigenere square. You have 5 minutes, working in pairs, to decode the message. | саси діхси а сору. |

| Codes and Ciphers | UNIT 1 Substitution Ciphers Lesson Plan 1 | Caesar Ciphers |
|-------------------------|--|---|
| Activity | | Notes |
| 3 (continued) | BPQA PIA JMMV APQNBML JG MQOPBT: Who has found the shift?(Shift forwards by 8)T: What is the message?(THIS HAS BEEN SHIFTED BY EIGHT) | Ps work in pairs: T monitors work but does not help unless no progress is being made. T asks volunteer P to give answer. |
| | T: How did you work it out? T: Did anyone use a different method? 25 mins | Discussion of reasons for methods used to tackle the problem. Feedback, self-correction. Praising. |
| 4 | Generalising | |
| | T: Why is going through each of the 26 possibilities an inefficient method of coding and decoding? (<i>Takes too long</i>) T: Can you think of other ways of tackling this problem? (?) T: One method is to consider the letter frequency. What letter do you think occurs most often? T: In fact, the first four most frequently used letters, in order, are | Interactive; T considers Ps' ideas, if possible. Are they feasible? If time, refer to the Sherlock Holmes story 'The Dancing Men'. Ps give ideas. Discuss what is meant by the 'most used' letters. |
| | E T A O T: Now try Exercise 4 to see if you can decode VXKT BT RWTTHT EATPHT 35 mins | T must ensure that Ps understand that, in a short passage of text, this will not always be the case. |
| 5 | Letter frequency | |
| | T: Let's try taking a short paragraph of text and finding the letter frequency. What do we need to help us? (<i>Tally chart</i>)T: Draw up a tally chart and write down the number of times each letter occurs in a passage of text of at least 100 letters. | Ps should be familiar with tally charts; if not, revise them now. Ps work in pairs. One P calls out letters, other P records on tally chart. T monitors, encourages. |
| | T: What are the four most frequently-occurring letters in your text? Are theyETAO ? | Discussion on why this result will not be true for each passage of text. |
| | T: Why do some of you have different results? (Too small a sample of text) | |
| | T: We can get a better idea by adding all your letter frequencies together. In turn, write your frequencies on this list. | Ps, in turn, write their results on table on OS 1.3 . |
| | 45 mins | |
| | HomeworkT: Take a passage of text of at least 300 words from any book and work out the letter frequency. Write the letter frequency in rank order, e.g.E T A O | |

| Codes and Ciphers | UNIT 1 <i>Substitution</i> <i>Ciphers</i> Lesson Plan 2 | Substitution Ciphers |
|-------------------------|--|--|
| Activity | | Notes |
| 1A | Martian alphabet T: The Martian alphabet has only 3 letters: How many different substitution ciphers can you find for the Martian alphabet? I'll give you 5 minutes to work out the answer. | Ps work in pairs: T monitors progress, intervening if necessary. Ps write in Ex.Bs. |
| | T: Who thinks that they have the correct answer? (6) How did you work it out? | Ps have probably listed all possibilities. Discussion. |
| 1B | T: The Venusian alphabet is similar but has one extra letter, namely . How many different substitution ciphers can you find for the Venusian alphabet? Don't write them all down - use the answer | T must encourage more mathematical thinking so introduces an extra letter. T monitors and gives just one |
| | for the Martian alphabet to help you. T: Write your answer on your slate/mini-whiteboard: show it now! (24) T: Why 242 (4 × 6) | hint. T checks which Ps have incorrect answers; discussion to find reasons for their mistakes. |
| | 1. Why 24. (4×0) | Agreement. Praising. |
| 1C | T: Now we can deduce the answer for an alphabet with 26 letters. What is it – as an expression? (26 × 25 × × 2 × 1) T (to P): Write the expression on the board. T: In fact, its value is 403 291 461 126 605 635 584 000 000 which is a little over 400 million million million. | Interactive, whole-class discussion. |
| Extension | T: What about an alphabet with <i>n</i> letters - how many different substitution ciphers will there be? $(n \times (n - 1) \times \times 2 \times 1)$ T: Well done; for convenience, we write this as n! = n.(n - 1).(n - 2)2.1 n! is pronounced ' <i>n</i> factorial'. T: What is the answer using the 'factorial' symbol for the Venusian alphabet? (4!) And for the English alphabet? (26!) | This need not be covered but it is a helpful way of writing a complex sum briefly and clearly. |
| 2 (continued) | Substitution ciphers T: What does this message say ZHCVHYP NYDCTG SJL GCMO T: Has anyone decoded it? T: How can we tackle this problem? (With frequency) T: Good idea. Before we do that, let's first review your homework. | Ps work individually or in pairs. T gives class 4 or 5 minutes to see if they can crack the code. Praise if anyone has succeeded, otherwise leave until later. |

| Codes and Ciphers | UNIT 1Substitution CiphersLesson Plan 2 | Substitution Ciphers |
|-------------------------|--|---|
| Activity | | Notes |
| 2 (continued) | T: Who agrees with the order E T A O for the first four letters? T: What are the next four letters? (Possibly N R I S) | Interactive discussion on rank order of letter frequency; let Ps display their first 10 letters in descending order of frequency, on the board. |
| | T: In fact, overall, in most extended passages of English text, the letter frequency is | OS 1.4 |
| | ETAONRISHDLFCUMGPYWBVKXJQZ | |
| | Use this to help decode the message above. | T gives Ps a few more minutes; monitors work, giving helpful hints, etc. |
| | 1: what is the message? T: Well done! (JANUARY BRINGS THE SNOW) | Agreement, self-correction. Praising. |
| | | T encourages Ps to discuss their approach. |
| | 30 mins | |
| 3 | ChallengeT: Working in pairs, look at the code on OS 1.5.Use all the facts you have learnt to help you to decode the message and to find the complete substitute alphabet. | At this stage Ps are just given OS 1.5 and the letter frequency table. |
| | | T monitors progress but does not help. |
| | T: What progress have you made? What letters are you sure about? | T intervenes after 10 minutes. |
| | T: Your task is to decode the passage. You can though use some hints if you think that you need them. You need to complete the task for homework | Interactive discussion, but T still does not give help. |
| | | T can give Hints 1-3 and Hints 4-6 in separate sealed envelopes (they are listed separately on OS 1.6 and OS 1.7). |
| | 45 mins | |
| | Homework | |
| | Complete the task of decoding the passage. | |
| | Can you complete the substitution cipher? | |
| | If not, why not? | |
| | Extension | |
| | Use the internet to find the letter frequencies in other alphabets, e.g. Welsh. | |
| | | |
| | | |
| | | |
| | | |