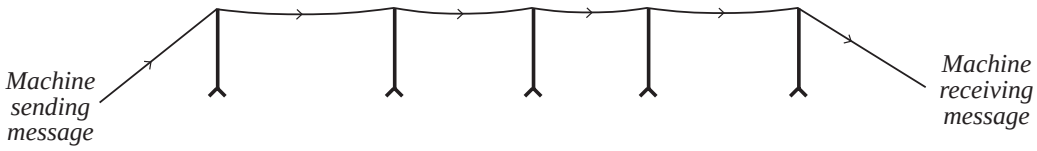
14 Morse Code

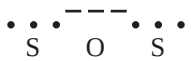
Morse code was invented by an American, Samuel Morse (1791-1872). Before the invention of the telegraph, messages that had to be sent over long distances were usually carried by messenger. These messages were delivered only as quickly as the fastest available horse could travel!

But in 1830, the first long distance telegraphic device was made by Joseph Henry (1797-1878) and Samuel Morse invented a telegraph system for sending messages using electricity. Messages were sent by tapping out a special code for each letter in the form of long or short signals. We will refer to them as 'dots' (short signals) and 'dashes' (long) although they were originally called 'dits' and 'dahs'. The code was converted into electrical impulses and sent over telegraph wires.



In 1844, Morse demonstrated the telegraph to the US Congress using the now famous message, "What hath God wrought" – a quotation from the Bible.

In 1851, an international conference in Berlin established an international version which is still in use today. You are probably familiar with the SOS message which is



Morse code requires the time for dots and dashes and the pauses after letters and words to be fairly standard, namely,

Character	*Time*
Dot	1 unit of time
Dash	3 units of time
Letter pause	3 "
Word pause	7 "

Example 1

What is the total time needed to send 'SOS'?

Solution

Letter	*Code*	*Time*
S	• • •	1 + 1 + 1 = 3
O	– – –	3 + 3 + 3 = 9
S	• • •	1 + 1 + 1 = 3

So for SOS you require the time for each letter plus 3 units of time between each letter

3 + 3 + 9 + 3 + 3 = 21 units of time

S ↑ letter pause O ↑ letter pause S

Note that the unit of time is arbitrary; experienced operators can achieve 20 to 30 words per minute!

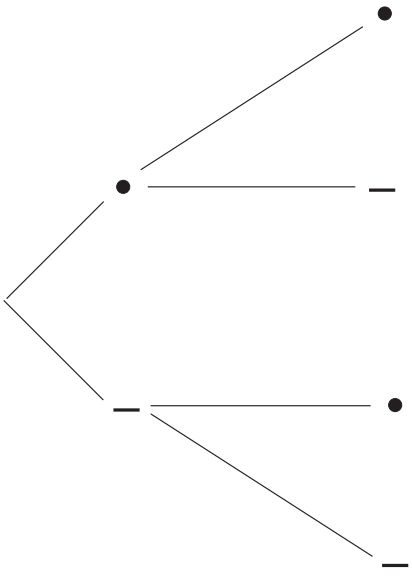
Activity 1

You could use different codes for the letters S and O to make the length of the message SOS shorter. What is the shortest length possible, using alternative codes for the letters? Why do you think that the shortest codes are not given to S and O?

In fact, Morse essentially used a letter count when devising his system; the letters with the highest frequencies were given the codes with the shortest transmission times. For letters of the alphabet, no code uses more than 4 dots or dashes in total but, as we have already seen, codes can consist of all dots, all dashes or combinations of both.

One way to find all the possible codes is to use a tree diagram.

Moving on from *one* dot (length 1) or *one* dash (length 3), the next set of codes has two dots/dashes, as shown below.



Code	*Length (in units of time)*
• •	2
• —	4
— •	4
— —	6

Activity 2

Complete the tree diagram in Appendix 1 and, for each letter code, calculate the length of the transmission time.

Activity 3

a) Make a list of codes and reorder them according to their transmission-time lengths. You can use the grid in Appendix 2 to help you.

b) The standard list of letters in descending order of frequency in the English language is

E T A O N R I S H D L F C U M G P Y W B V K X J Q Z

Allocate this according to the list of transmission-time lengths in part a) in Appendix 2. This gives an efficient method of coding.

c) The full set of code in transmission-time lengths is given in Appendix 3. Using the accepted Morse code given in Appendix 4, complete the letters table in Appendix 3. Compare your answer to part b) with this. How much agreement is there between the two codes?

You should see that there is good agreement between the actual Morse code and the ones that you have devised.

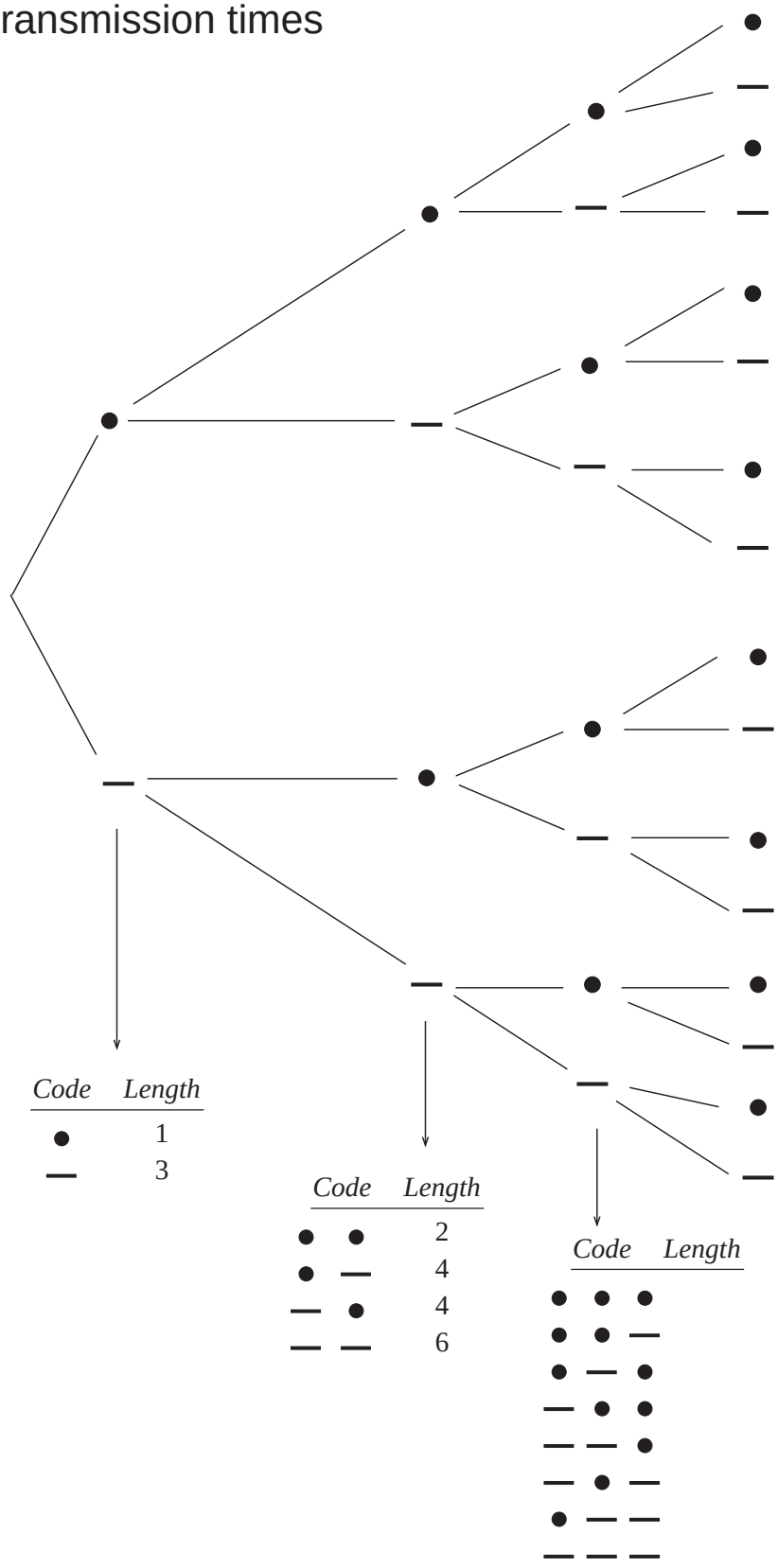
Activity 4

Which possible codes are not used in Morse code? Do they correspond to codes of maximum transmission time length? What could they have been used for?

Despite its age, Morse code is still used today and will always remain a viable means of providing highly reliable communications during difficult conditions, especially when other more technology-based means have failed. It has survived for over 150 years and its longevity is a tribute to the effective original design by Samuel Morse.

Appendix 1

Possible codes with length of transmission times



Appendix 2

Possible codes in transmission-time length order

Possible codes	***Transmission time***	***Letters in frequency order***
●	1	E
● ●	2	T
—	3	A
● ● ●	3	O
		N
		R
		I
		S
		H
		D
		L
		F
		C
		U
		M
		G
		P
		Y
		W
		B
		V
		K
		X
		J
		Q
		Z

Appendix 3

Codes in transmission-time length order

Code	*Transmission time*	*Letter in Morse code*
●	1	E
● ●	2	I
—	3	
● ● ●	3	
● —	4	
— ●	4	
● ● ● ●	4	
● ● —	5	
● — ●	5	
— ● ●	5	
— —	6	
● ● ● —	6	
● ● — ●	6	
● — ● ●	6	
— ● ● ●	6	
— — ●	7	
— ● —	7	
● — —	7	
● ● — —	8	
● — ● —	8	
● — — ●	8	
— ● ● —	8	
— ● — ●	8	
— — ● ●	8	
— — —	9	
● — — —	10	
— ● — —	10	
— — ● —	10	
— — — ●	10	
— — — —	12	

Appendix 4

Morse code

A	• —	N	— •
B	— • • •	O	— — —
C	— • — •	P	• — — •
D	— • •	Q	— — • —
E	•	R	• — •
F	• • — •	S	• • •
G	— — •	T	—
H	• • • •	U	• • —
I	• •	V	• • • —
J	• — — —	W	• — —
K	— • —	X	— • • —
L	• — • •	Y	— • — —
M	— —	Z	— — • •