Unit 2 · Data in Depth

ANSWER KEY · FOR TEACHERS

Full marks 34

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

K · 4

1. base
2. hexadecimal
3. two's complement
4. code point
5. color depth
6. run-length encoding
7. lossless
8. lossy

Each carries 0.5 mark.

2 Label the diagram

U · 2

1. loud tone: kept
2. can't be heard
3. quiet tone hidden by the loud one: not stored
4. quiet tone heard: kept

Each carries 0.5 mark.

3 Multiple choice

i. **a.** $(11001)_2$ — A · 1

14 + 11 = 25 = 16 + 8 + 1 = $(11001)_2$. Column by column: 0 + 1 = 1; 1 + 1 = 10 (write 0, carry 1); 1 + 0 + 1 = 10 (write 0, carry 1); 1 + 1 + 1 = 11 (write 1, carry 1); then the carry 1. (10101 is what you get if you forget the carries.)

ii. **a.** $(101011)_2$ — A · 1

Each octal digit is three bits: 5 = 101 and 3 = 011, so $(53)_8 = (101011)_2 = 43$. (110101 is fifty-three in decimal, a trap: $(53)_8$ is not fifty-three. 10111 writes the 3 as 11, only two bits: every octal digit must be written as three, 011.)

iii. **b.** 11111110 — A · 1

2 is 00000010; flip it to 11111101 and add 1: 11111110. Check: −128 + 126 = −2. (11111101 is −3; 10000010 is −126.)

iv. **d.** 15 — U · 1

ज्ञान is 5 code points: ज, the halant ्, ञ, the vowel sign ा and न. Each Devanagari code point takes 3 bytes in UTF-8: 5 × 3 = 15 bytes. (3 is the number of letters you might count by eye: ज्ञा and न.)

v. **b.** 1,250 — A · 1

100 × 100 × 1 = 10,000 bits, and 10,000 ÷ 8 = 1,250 bytes. (10,000 is the bits, the trap; 30,000 would be 24-bit color.)

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4 Trace the program

ANSWER A · 4

r	answer	n	**Output**
(before)	""	725	
5	"5"	90	
2	"25"	11	
3	"325"	1	
1	"1325"	0	
			1325

The program changes 725 to octal: $(725)_{10} = (1325)_8$. Check: 1 × 512 + 3 × 64 + 2 × 8 + 5 = 512 + 192 + 16 + 5 = 725.

MARKING SCHEME

- ✓ r 5, 2, 3, 1: the remainders of 725, 90, 11 and 1 divided by 8.
- ✓ n 90, 11, 1, 0: each quotient (//).
- ✓ answer grows at the front: "5", "25", "325", "1325".
- ✓ Output 1325, once, after the loop stops at n = 0.

5 Short answers

a. **MARKING SCHEME** A · 2

- ✓ i. $(10101)_2$. Check: 44 - 23 = 21.
- ✓ ii. 1101 + 110100 (1101 shifted two places) = $(1000001)_2$. Check: 13 × 5 = 65.

b. **MARKING SCHEME** A · 3

- ✓ i. 45 = 00101101, flipped 11010010, add 1: 11010011.
- ✓ ii. -128 + 64 + 16 + 4 + 2 = -42.
- ✓ iii. 01000110 + 11010011 = 1 00011001: the carry off the left end is dropped, leaving 00011001 = 25.

c. **MARKING SCHEME** U · 2

- ✓ स्त्री is 6 code points (स, ◌्, त, ◌्, र, ◌ी), and each Devanagari code point takes 3 bytes in UTF-8: 6 × 3 = 18.
- ✓ stree is 5 ASCII letters, each below U+0080, so 1 byte each: 5 bytes.

d. **MARKING SCHEME** A · 2

- ✓ i. 8B 4W 12B: 3 runs = 6 bytes instead of 24, a ratio of 4 : 1.
- ✓ ii. WWWBBWWWWW.

6 Numerical problems

a. **ANSWER** A · 2

256 colors need 8 bits a pixel ($2^8 = 256$).
Size = 800 × 600 × 8 = 3,840,000 bits = 3,840,000 ÷ 8 = 480,000 bytes.
In KB: 480,000 ÷ 1,024 ≈ **469 KB** (468.75).

MARKING SCHEME

- ✓ 8 bits a pixel, so 800 × 600 × 8 = 3,840,000 bits = 480,000 bytes.
- ✓ 480,000 ÷ 1,024 ≈ 469 KB.

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b. ANSWER A · 3

i. 2 minutes = 120 seconds. 48,000 × 16 × 2 × 120 = 184,320,000 bits = 23,040,000 bytes. ÷ 1,024 ÷ 1,024 ≈ **22.0 MB**.

ii. 192,000 × 120 = 23,040,000 bits = 2,880,000 bytes. ÷ 1,024 ÷ 1,024 ≈ **2.7 MB**.

iii. 23,040,000 ÷ 2,880,000 = **8 : 1**.

MARKING SCHEME

✓ 48,000 × 16 × 2 × 120 = 184,320,000 bits = 23,040,000 bytes ≈ 22.0 MB.

✓ 192,000 × 120 = 23,040,000 bits = 2,880,000 bytes ≈ 2.7 MB.

✓ 23,040,000 ÷ 2,880,000 = 8 : 1 (22.0 ÷ 2.7 ≈ 8 also gets the mark).

7 True or false

U · 3

i. ✓ **True**

ii. ✗ **False:** The detail is gone for good: it only makes a bigger file of the same blurry picture.

iii. ✓ **True**

iv. ✗ **False:** A program must stay exact: one changed character can stop it working, so it needs lossless compression.

v. ✓ **True**

vi. ✗ **False:** It keeps the brightness of every pixel, and one color for each 2 × 2 square.

Each carries 0.5 mark.

8 Think

ANSWER HA · 2

The second ZIP file is about the same size, 10 MB, or even a little bigger. A good compressed file has had its patterns squeezed out already: what is left looks random, and random data has no pattern to find. In fact no lossless method can shrink **every** file: there are far fewer short files than long ones, so if some files get shorter, others must get longer. Compression works because the files people make, text, drawings, programs, are full of patterns.

MARKING SCHEME

✓ The ZIP file stays about 10 MB (or gets a little bigger): its patterns have already been squeezed out, and what is left looks random.

✓ Lossless compression works only by finding patterns, so it can't shrink every file; data with no pattern doesn't shrink.

9 Activity: Squeeze the same photo

(not marked)

WHAT STUDENTS SHOULD FIND

The PNG is the biggest by far. JPEG 80 is many times smaller and looks almost the same. At 40 the file is smaller again, and blocks and smudges start to show, first on sharp edges and smooth sky; at 5 the picture is badly damaged. For sending a photo, a quality of about 70 to 85 is usually the best bargain: most of the saving, none of the damage.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	4	8	20	2	**34**

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