Analog or Digital? Signals and Noise

Grades 6-8

Name _____ Date _____

Directions: An analog signal changes smoothly and can take any value in between. A digital signal uses only a fixed set of separate values, such as on and off. For items 1 to 4 write analog or digital on the line. Use the tables for items 5 to 7.

Table 1 (SIMULATED data): a light sensor on a windowsill

Time (s)	0	2	4	6	8	10
Brightness level	3	5	8	8	6	2

Table 2 (SIMULATED data): eight pulses arriving through a long cable

Pulse number	1	2	3	4	5	6	7	8
Height received	88	61	12	34	93	7	72	45
Bit (item 7)								

Both tables are simulated: nobody measured these numbers, they were invented for this page. Brightness runs from 0 (dark) to 10 (full sun). Every pulse in Table 2 left the sender at a height of exactly 0 or exactly 100.

1. The red liquid in a glass thermometer creeps smoothly up the tube as a greenhouse warms through the morning. _____

2. The needle on a truck's speed dial sweeps past the numbers without jumping as the truck speeds up. _____

3. A concert ticket carries a square code made of small boxes, and every box is printed either black or white. _____

4. A text message leaves a phone as a long string of 0s and 1s. _____

5. Read Table 1. (a) Which brightness level did the sensor store at 6 s? _____ (b) Between which two neighboring readings did the brightness fall the most? from _____ s to _____ s

6. The sunlight outside changed smoothly all morning. Is Table 1 an analog record or a digital record of that sunlight? Give one reason from the table.

7. Use Table 2. The receiver follows one rule: a height above 50 is read as 1, and a height below 50 is read as 0. Write the bit (1 or 0) for each of the 8 pulses in the empty row of the table.

8. A song file is passed from phone to phone forty times, and the last copy plays exactly like the first. Explain how the rule in item 7 keeps small amounts of noise from building up in a digital copy, and say what happens to noise when an analog signal is copied.

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Answer key

Items 1 to 4: one point each. Item 5: two points. Item 6: two points (answer and reason). Item 7: one point for all eight bits. Item 8: two points.

1. **analog**
   The liquid can stop at any height, with no steps between one value and the next.

2. **analog**
   The needle passes through every position in between.

3. **digital**
   Only two separate values are allowed for each box.

4. **digital**
   The message is carried by just two symbols.

5. **(a) 8 (b) from 8 s to 10 s**
   The level falls by 4 (from 6 to 2), more than between any other pair of readings.

6. **Digital. The table keeps separate readings at set times, and each reading is one value from a fixed list (0 to 10), not a smooth, unbroken curve.**
   Accept either reason: readings only at separate moments (every 2 s), or only whole-number levels from a fixed list (0 to 10).

7. **1 1 0 0 1 0 1 0**
   Compare each height with 50 only. The pulse nearest the threshold (45) still falls on the low side, which makes it a 0.

8. **Each receiver only decides which side of the threshold a pulse falls on, then sends on a fresh, full-size pulse. Small noise is thrown away at every step, so it never adds up. An analog copy keeps the whole shape, noise included, so each generation of copies ends up noisier than the one before.**
   Two ideas earn the points: the threshold decision removes small noise, and analog copying has no way to tell noise from signal. Very large noise can still flip a bit.