

Radio to gamma waves and digital signals

Grade 8 science (Year 9 · Class 8) · Worksheet answers

Check your method against these model answers. Calculations show the formula, the substitution and the result in bold. For wave problems, convert the frequency to hertz before dividing, and for binary problems, write the place values above the digits.

Level: Grade 8 science (Year 9 · Class 8) · **Curriculum:** MS-PS4-3

Problem 1 Order of the spectrum

1. **Radio, microwave, infrared, visible light, ultraviolet, X-ray, gamma.**
2. Radio waves have the longest wavelength: **radio**.
3. Gamma rays have the highest frequency and the most energy: **gamma**.

Problem 2 Speed of EM waves

1. The speed is **3.0×10^8 m/s**.
2. No. EM waves can travel through a vacuum, so they **do not need a material**.
3. They have the **same speed**; neither is faster.

Problem 3 Match the use

1. **Infrared.**
2. **X-rays.**
3. **Microwaves** (radio waves are also used in some links).
4. **Gamma rays.**
5. **Ultraviolet.**

Problem 4 Analogue or digital

1. **Analogue**, because the mercury can stop at any height.
2. **Digital**, because it is stored as 1s and 0s.
3. **Analogue**, because brightness changes continuously.
4. **Digital**, because there are only two states.

Problem 5 Binary basics

1. The digits are **0 and 1**.
2. One byte is **8 bits**.
3. $101 = 4 + 0 + 1 =$ **5**.

Problem 6 Decimal to binary

1. $6 = 4 + 2$, so **0110** (110).
2. $9 = 8 + 1$, so **1001**.
3. $12 = 8 + 4$, so **1100**.
4. $15 = 8 + 4 + 2 + 1$, so **1111**.

Problem 7 AM radio wavelength

1. $900 \text{ kHz} = 900 \times 10^3 \text{ Hz} = \mathbf{9.0 \times 10^5 \text{ Hz}}$.
2. $\lambda = v \div f = 3.0 \times 10^8 \div 9.0 \times 10^5 = 333 \text{ m}$, which is **$3.3 \times 10^2 \text{ m}$** .
3. They are **radio waves**.

Problem 8 Microwave oven

1. $2.45 \text{ GHz} = 2.45 \times 10^9 \text{ Hz}$.
2. $\lambda = 3.0 \times 10^8 \div 2.45 \times 10^9 = 0.122 \text{ m}$, which is **12.2 cm**.

Problem 9 Frequency of light

1. $\lambda = 7.00 \times 10^{-7} \text{ m}$, so $f = 3.0 \times 10^8 \div 7.00 \times 10^{-7} = \mathbf{4.3 \times 10^{14} \text{ Hz}}$.
2. $\lambda = 4.00 \times 10^{-7} \text{ m}$, so $f = 3.0 \times 10^8 \div 4.00 \times 10^{-7} = \mathbf{7.5 \times 10^{14} \text{ Hz}}$.
3. **Violet** has the higher frequency because its wavelength is shorter.

Problem 10 Wavelengths in a table

1. 1 km: **radio**. 10 cm: **microwave**. $10 \mu\text{m}$: **infrared**. 500 nm: **visible light**. 100 nm: **ultraviolet**. 1 nm: **X-ray**. 0.001 nm: **gamma**.
2. The shortest wavelength has the highest frequency: **gamma rays**.

Problem 11 Sunburn on a cloudy day

1. **Ultraviolet** radiation.
2. UV has a higher frequency than visible light, so its waves carry more energy and can damage the DNA in skin cells. It also passes through thin cloud.
3. Wear sunscreen, a hat or cover the skin: **sunscreen or a hat**.

Problem 12 Spot the errors

1. All EM waves travel at the same speed in a vacuum: **$3.0 \times 10^8 \text{ m/s}$** .
2. A digital signal has **only two levels**, 0 and 1, and nothing between.

Problem 13 Binary to decimal

1. From the left the place values are **16, 8, 4, 2, 1**.
2. $16 + 0 + 4 + 2 + 0 = \mathbf{22}$.

3. $16 + 8 + 0 + 0 + 1 = 25$.

Problem 14 Reading a wave graph

1. Distance between crests = $5.0 - 1.0 = 4.0 \text{ m}$.
2. $f = v \div \lambda = 3.0 \times 10^8 \div 4.0 = 7.5 \times 10^7 \text{ Hz}$.
3. $7.5 \times 10^7 \text{ Hz} = 75 \text{ MHz}$.

Problem 15 Rebuilding a digital signal

1. The pulses are high, high, low, high, low, low, high, low: **11010010**.
2. Each pulse is clearly above or below the threshold, so the receiver can decide 1 or 0 and rebuild a clean signal. **The threshold removes the noise.**
3. The noise would stay in the signal and be amplified with it.

Problem 16 Wi-Fi bands

1. At 2.4 GHz: $\lambda = 3.0 \times 10^8 \div 2.4 \times 10^9 = 0.125 \text{ m}$. At 5.0 GHz: $\lambda = 3.0 \times 10^8 \div 5.0 \times 10^9 = 0.060 \text{ m}$.
2. $0.125 \div 0.060 = 2.1 \text{ times}$ longer.
3. The higher frequency, **5.0 GHz**, carries more energy.

Problem 17 Downloading a file

1. $15 \text{ MB} \times 8 = 120 \text{ Mbit}$.
2. Time = $120 \div 20 = 6.0 \text{ s}$.
3. $2^{10} = 1024$ values.

Problem 18 Satellite TV delay

1. $36\,000 \text{ km} = 3.6 \times 10^7 \text{ m}$, so up and down is $2 \times 3.6 \times 10^7 = 7.2 \times 10^7 \text{ m}$.
2. $t = d \div v = 7.2 \times 10^7 \div 3.0 \times 10^8 = 0.24 \text{ s}$.
3. **Microwaves** (or radio waves).

Problem 19 Choosing the right wave

1. **X-rays**. They pass through soft tissue but are absorbed by bone, so bone shows on the image.
2. **Infrared**. Warm objects give out more infrared, which a thermal camera detects in the dark.
3. X-rays are ionising and can damage cells, so repeated exposure raises the risk of harm. **Staff limit their exposure.**

Problem 20 Sending letters in binary

1. $C = 3 = 00011$, $A = 1 = 00001$, $B = 2 = 00010$. The message is **00011 00001 00010**.
2. $01000 = 8 = H$ and $00101 = 5 = E$, so the message is **HE**.
3. $\text{Bits} = 120 \times 5 = 600$, so $\text{time} = 600 \div 2400 = \mathbf{0.25\ s}$.