2019 Ph H2 Q5

Section: Particles and Waves
Topic: Doppler Effect

Summary:
This question examines the change in observed frequency due to motion (the Doppler effect) and the application of ultrasound in medical imaging to determine blood flow velocity.

(a)(i)
State the name given to this effect.
▶️ **Answer: Doppler effect**

✅ **Mark: 1**

(a)(ii)
Calculate the frequency of the sound heard as the car approaches.

> Given:
> Speed of source $v_s = 12\,\mathrm{m\,s^{-1}}$
> Speed of sound $v = 340\,\mathrm{m\,s^{-1}}$
> Source frequency $f = 510\,\mathrm{Hz}$
>
> For a stationary observer and source approaching:
> $$f' = \frac{v}{v - v_s} f = \frac{340}{340 - 12} \times 510 = \frac{340}{328} \times 510 \approx 529.3\,\mathrm{Hz}$$

▶️ **Answer:** $529\,\mathrm{Hz}$
✅ **Marks: 3**

- 1 mark: correct formula
- 1 mark: correct substitution
- 1 mark: correct final answer

(b)
Calculate the velocity of the red blood cells during the test.

> Given:
> $\Delta f = 286\,\mathrm{Hz}$
> $f = 3.70 \times 10^6\,\mathrm{Hz}$
> $v = 1540\,\mathrm{m\,s^{-1}}$
> $\theta = 60.0^\circ$
>
> Doppler shift for reflected wave:
> $$\Delta f = \frac{2 f v_{\text{rbc}} \cos\theta}{v} \Rightarrow v_{\text{rbc}} = \frac{\Delta f \cdot v}{2 f \cos\theta}$$
> $$= \frac{286 \times 1540}{2 \times 3.70 \times 10^6 \times \cos 60^\circ} = \frac{440440}{2 \times 3.70 \times 10^6 \times 0.5} = \frac{440440}{3.70 \times 10^6} \approx 0.119\,\mathrm{m\,s^{-1}}$$

▶️ **Answer:** $0.12\,\mathrm{m\,s^{-1}}$
✅ **Marks: 2**

- 1 mark: correct relationship and substitution
- 1 mark: correct final answer

🔁 **Revision Tips:**

- Doppler effect applies to sound and light.
- For sound:
  - **Approaching** source: observed frequency **increases**
  - **Receding** source: observed frequency **decreases**
- Reflected ultrasound from moving targets (e.g. blood cells) leads to **frequency shifts**, allowing speed measurement.
- Always check whether it's **reflected Doppler** (factor of 2 included).