(**b**) As the amplitude varies, this will occur first

when $\frac{4\pi^2 A}{T^2} = g$ i.e. $A = \frac{T^2 g}{4\pi^2}$

Substituting the data provided,

$A = \frac{0.50^2 \times 9.81}{4\pi^2} = 0.062\text{ m} = 6.2\text{ cm}$ (3)

C.5

Exercises

1 0.06 *c*

2 4.38 nm

3 $3.17 \times 10^7\text{ m s}^{-1}$

4 $3.25 \times 10^7\text{ m s}^{-1}$; it is further away since it is moving fast

5 2.1 Mpc

6 1440 km s^{-1}

Practice questions

1 (**a**) circular wavefronts originating from four successive source positions; bunching of wavefronts in front, spreading out at back; approximately, correct spacing of wavefronts in front, and behind source (3)

(**b**) $\lambda' = \lambda\frac{(V - v)}{V}$;

$5999.996 = \frac{600 \times (3 \times 10^8 - v)}{3 \times 10^8}$;

$v = 2000\text{ m s}^{-1}$ (3)

Allow alternative version for red shift.

2 B (1)

3 D (1)

4 D (1)

5 A (1)

6 C (1)

7 (**a**) mention of Doppler effect ***OR*** relative motion between source and observer produces frequency/wavelength change;

*Accept answers which refer to a double frequency shift. Award **[0]** if there is any suggestion that the wave speed is changed in the process.*

the reflected waves come from an approaching "source" ***OR*** the incident waves strike an approaching "observer";

increased frequency received by the device ***or*** by the car (2)

(**b**) ***ALTERNATIVE 1***

the car is a moving "observer" and then a moving "source"; so the Doppler effect occurs twice (2)

ALTERNATIVE 2

the reflected radar appears to come from a "virtual image" of the device; traveling at $2v$ toward the device (2)

(**c**) *For both alternatives, allow ecf to conclusion if v **OR** Δf are incorrectly calculated.*

ALTERNATIVE 1

$v = \frac{(3 \times 10^8) \times (9.5 \times 10^3)}{(40 \times 10^9) \times 2} = 36\text{ m s}^{-1}$;

36 > 28 so car exceeded limit (2)

There must be a sense of a conclusion even if numbers are not quoted.

ALTERNATIVE 2

reverse argument using speed limit.

$\Delta f = \frac{2 \times 40 \times 10^9 \times 28}{3 \times 10^8} = 7500\text{ Hz}$;

9500 > 7500 so car exceeded limit (2)

There must be a sense of a conclusion even if numbers are not quoted.

(**d**) speed of sound relative to the microphone is less; wavelength unchanged so frequency is lower ***OR*** fewer waves recorded in unit time/per second so frequency is lower (2)

(**e**) $845 = 850 \times \frac{340 - v}{340}$;

$v = 2.00\text{ m s}^{-1}$ (2)

8 (**a**) A; because it is the point nearest the Earth (2)

(**b**) C; because it is the point moving fastest toward the Earth (2)

D.1

Exercises

1 1.61 m s^{-2}

2 24.7 N kg^{-1}

3 7.34 N kg^{-1}

4 $6.69 \times 10^{-8}\text{ N kg}^{-1}$

5 0 N kg^{-1}

6 graph of T^2 vs. r^3

7 $4.2 \times 10^7\text{m}$

8 1.5 hours

Practice questions

1 A (1)

2 D (1)

3 C (1)