


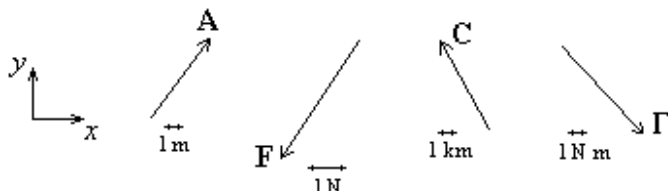
Solutions to those problems that are marked with an asterisk in this book .

Chapter 1.

1. (i) 6 or 6.28318 if 2 is taken to be an integer.
 (ii) 6.28 .
 (iii) 1.404×10^{-5} (treat the index -3 as an integer).
 (iv) 81.4 (81.4 \pm 0.9)
 (v) 1.01
3. (i) 36.01 \pm 0.005
 (ii) 36.0 \pm 0.05
 (iii) 0.181 \pm 0.002
 (iv) 20 \pm 1
 (v) 0.020 \pm 0.001
5. (i) 36.68 \pm 0.38 or 36.7 \pm 0.4
 (ii) 32.52 \pm 0.38 or 32.5 \pm 0.4
 (iii) 72.0 \pm 6.6 or 72 \pm 7
 (iv) 16.6 \pm 1.6 or 17 \pm 2
 (v) 115 \pm 8
7. 10.50, 10.5, 10 . 100.5 or 101
9. Mean 0.333, standard deviation 0.016.
11. Three significant figures. 1571/500.
13. 
15. There are about 5×10^9 people on the earth (if you want to argue the point here you haven't caught on to the spirit of estimation). A bucket contains about 10 litres (10^{-2} m³) and a grain of sand is about 0.3 mm across, this gives 4×10^8 grains of sand; a comparable but smaller figure.
17. My rectangle has corners at (0.75,2.52), (1.0,2.4), (9.6,6.95) and (9.9,6.8).
 The diagonals indicate a slope of 0.50 ± 0.03 , a line with this slope must pass through the mean values (4.71,4.34) giving a constant of 2.0 ± 0.1 ,
 $y = .5x + 2.0$.

Chapter 2.

1.



2. $|\mathbf{A}| = 5.0$ m , $|\mathbf{F}| = 3.6$ N , $|\mathbf{C}| = 5.2$ km and $|\mathbf{G}| = 5.7$ N m .
3. $\theta_{\mathbf{A}} = 53^\circ$, $\theta_{\mathbf{F}} = 236^\circ$, $\theta_{\mathbf{C}} = 119^\circ$ and $\theta_{\mathbf{G}} = 313^\circ$ or -47° .
7. $|\mathbf{D} + \mathbf{G}| = 8.8$ km , $|\mathbf{D} - \mathbf{G}| = |\mathbf{G} - \mathbf{D}| = 62.7$ km .

9. 4.2 km from the start. Go 4.2 km at 23° south of west.
11. 174° , 156° .
13. Between **A** and **B**, 48° . Between **D** and **G**, 175° .
15. Sum $(-0.8, 17.2)$ m. Sum plus difference $(3.2, 2.6)$ m, length 4.1 m at 39° from the x -axis.
17. Bearing 117° . Relative velocity 4.0 km hr^{-1} to the north so the relative speed is 4.0 km hr^{-1} .

Chapter 3.

1. 32.2 km hr^{-1} , 8.94 m s^{-1} .
 3. $\bar{v} = 13.8 \text{ m s}^{-1}$, $v = 0.75t + 10 \text{ m s}^{-1}$.
 5. 4.0 m s^{-1} , 0.
 7. If the speed changes abruptly: $s = 20+23+26+29+32+35 = 165 \text{ m}$. For smooth change (constant a): $s = v_0t + \frac{1}{2}at^2 = 120 + 0.375 \times 144 = 174 \text{ m}$. Either could be correct, depending on how you chose to interpret the data.
 - 9.
- | | | | | | | | | | | | |
|-----|---|--------|-------|-------|-------|-------|-------|-------|-------|-------|------------------------|
| t | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 s |
| v | 0 | -0.98 | -1.96 | -2.94 | -3.92 | -4.9 | -5.88 | -6.86 | -7.84 | -8.82 | -9.8 m s^{-1} |
| s | 0 | -0.049 | -0.20 | -0.44 | -0.78 | -1.44 | -1.76 | -2.40 | -3.14 | -3.97 | -4.9 m |
11. Probably not, he spends extra time accelerating from rest in the first ten seconds. 10 m s^{-1} then 10.2 m s^{-1} . 36 km hr^{-1} , 36.7 km hr^{-1} . To reach 10 m s^{-1} from rest takes 0.5 s, distance taken is about 2.5 m. Remember that these figures are approximations.
 13. 20 m s^{-1} and 20 m. 28.6 m s^{-1} , from $s = \frac{1}{2}at^2$ we get $a = 4.2 \text{ m s}^{-1}$.
 15. 2.65 times.
 17. 34.7 m.
 19. For the harmonic motion $v = -\omega A \sin(\omega t) = -0.0275 \sin(0.11t)$; this is not the same mathematical form as $v = v_0 + at$. Maximum speed is $\omega A = 0.0275$, while the maximum acceleration is $\omega^2 A = 3.03 \times 10^{-3} \text{ m s}^{-2}$.

Chapter 4.

1. 59 m s^{-1} towards the waterfall, or 58 m s^{-1} if the mass of the boots is included with the mass of the traveler, this is an impossibly fast throw. 4.7 m s^{-1} .
2. 0.80 m s^{-1} , 0.80 m s^{-1} and 0.8 m s^{-1} , the momentum and hence speed of the whole system can't change.
5. 9.1 m s^{-1} , 5300 N for both players and 3.8 m s^{-1} .
7. 96 N against motion, 64 N upwards, 115 N.
9. 945 N and 22. s. (To two significant figures 950 N and 22s.)
11. For A: $+100 \text{ kg m s}^{-1}$ and -11 kg m s^{-1} ; for B: -120 kg m s^{-1} and -9 kg m s^{-1} . $F_A = F_B = 5.0 \text{ N}$.
13. $F_1 = 270 \text{ N}$, $F_2 = 130 \text{ N}$; $F_1 = 200 \text{ N}$, $F_2 = 200 \text{ N}$; $F_1 = 130 \text{ N}$, $F_2 = 270 \text{ N}$.

$$15. \quad |\mathbf{f}_1| = \frac{s_2}{s_1} |\mathbf{F}| = |\mathbf{f}_2|$$

Chapter 5.

- 2330 N.
- 8440 N.
- Both sledge and traveler change momentum by 78 kg m s^{-1} , in each case they experience an equal and opposite forces of $78/\Delta t$ or 156 N if $\Delta t = 0.5 \text{ s}$.
- $g \sin\theta = 4.9 \text{ m s}^{-2}$, $Mg \cos\theta = 346 \text{ N}$, $Mg \sin\theta = 200 \text{ N}$. $a_p = 4.4 \text{ m s}^{-2}$.
- 220 N, 261 N, 139 N.
- $a = 0.24 \text{ m s}^{-2}$, m_2 , goes down. $T = 10.0 \text{ N}$ but $F = 2T = 20.1 \text{ N}$.
- $a = 1.64 \text{ m s}^{-2}$. Yes, $a = \frac{(m_2 - m_1 \sin\theta)g}{m_1 + m_2}$ requires $m_1 < m_2/\sin\theta$.
- 0.083 m s^{-2} , 2500 J, 6930 N.
- 29.7 m s^{-1} .
- 10.5 m s^{-1} (-ive x), 7.5 m s^{-1} .

Chapter 6.

- 5060 s, or 84 minutes.
- $36 \times 10^6 \text{ m}$.
- Gravitation force $1.4 \times 10^{-51} \text{ N}$; Electric force $5.8 \times 10^{-9} \text{ N}$.
- $2.2 \times 10^6 \text{ m s}^{-1}$. $1.5 \times 10^{-16} \text{ s}$, $6.6 \times 10^{15} \text{ Hz}$.
- At 110 km, $3.08 \times 10^{10} \text{ J}$; at 1100 km, $2.67 \times 10^{10} \text{ J}$.

$$\frac{1}{2}mv^2 = \frac{Gm_e m}{2(R_e + h)} = \frac{2.0 \times 10^{17}}{(R_e + h)} \text{ J}$$

- The answer for this particular question is -11.3 mm. If the charges had the same value but like signs (both + or both -) then the answer would be 3.3 mm.
- 3.3 mm.

$$13. \text{ x-comp. } E_{Ax} = k_e \left(\frac{2 \times 10^{-15}}{13 \times 10^{-6}} \frac{2}{\sqrt{13}} - \frac{3 \times 10^{-15}}{10 \times 10^{-6}} \frac{1}{\sqrt{10}} \right) = -0.086 \text{ N C}^{-1}$$

$$\text{y-comp. } E_{Ay} = k_e \left(\frac{2 \times 10^{-15}}{13 \times 10^{-6}} \frac{3}{\sqrt{13}} - \frac{3 \times 10^{-15}}{10 \times 10^{-6}} \frac{3}{\sqrt{10}} \right) = -1.41 \text{ N C}^{-1}$$

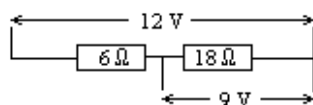
Chapter 7

- $\text{N C}^{-1} = \text{N m C}^{-1} \text{ m}^{-1} = \text{J C}^{-1} \text{ m}^{-1} = \text{V m}^{-1}$.
- 300 m s^{-2} , 3.5 m s^{-1} .
- 0.0114 s and 0.0067 s.
- 250 kV, we cannot be too precise with this answer as our non-relativistic equations are inaccurate as the speed approaches $3 \times 10^8 \text{ m s}^{-1}$.
- 6.3×10^{18} , $4 \times 10^{-10} \text{ m}^3$, $4 \times 10^{-4} \text{ m}$, $4 \times 10^{-4} \text{ m s}^{-1}$.

10. (c), $14\,000\text{ V m}^{-1}$, $1.2 \times 10^4\text{ m s}^{-1}$.
11. 0.04 C .
13. 5 V , 2.5 W , 38 J .

Chapter 8

1. $I = 1.0\text{ A}$, $V = 9.0\text{ V}$.
3. $I = 3.0\text{ A}$, $V = 27\text{ V}$.
5. 2.0 A through, and 18 V across the series resistor; 1.0 A through and 9.0 V across the parallel resistors.
7. The maximum values of possible resistors are shown below, the the $18\ \Omega$ resistance will be reduced when the tape recorder is connected in parallel across it.



9. 3.75 mV (we use three significant figures because this is probably a precise value).
10. $R_s = 0.0152\ \Omega$.
11. $399\ \Omega$.

Chapter 9.

1. $0.71r$, $0.50r$.
3. $2.0 \times 10^7\text{ N}$, $1\,260\text{ A}$.
5. Down
7. The field is at 45° to both wires. $B = 1.9 \times 10^{-6}\text{ T}$.
9. $8.4 \times 10^6\text{ m s}^{-1}$; $9.5 \times 10^4\text{ m}$. Yes, if the electron travels parallel to the field.
11. $F = 0.56\text{ N}$ in each case. Moment(a) = 0.028 N m , moment(b) = 0.020 N m , moment(c) = 0 .

Chapter 10.

1. $0.68 \times 10^{-3}\text{ T m}^2$ (Wb) or zero.
3. 0.15 V
5. 2.5 mA
8. About 1.6 s .
10. $3\,000\text{ V}$; $1.8 \times 10^{-3}\text{ T m}^2$ per turn.
12. (i) A to B, (ii) little if any, (iii) B to A.

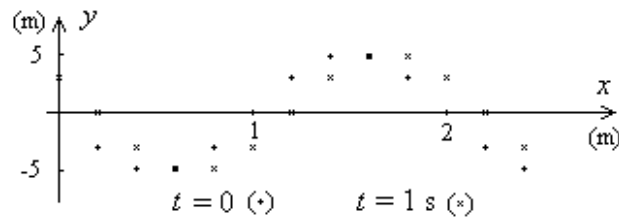
Chapter 11.

1. $k = 200\text{ N m}^{-1}$, $x_0 = 0.60\text{ m}$.
2. 300 m s^{-2} , 2.9 Hz .
- 5.

$$y = A \sin(\omega t) + A \sin(\omega t)$$

0.05 m, 0.913 m s^{-1} and 16.7 m s^{-2} .

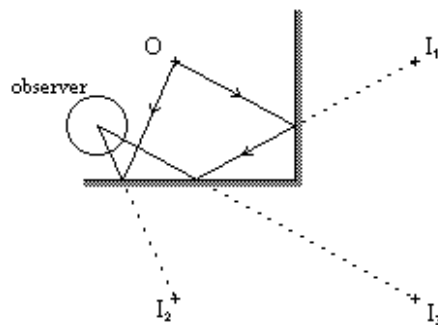
8. $y = -4.94 \text{ m}$.
10. $x - 0.5 = 4.65 \text{ m}$.
- 12.



14. 333 m s^{-1} , 318 Hz . Nodes at $x = \dots -0.262, 0.262, 0.785, \dots$; wavelength is 0.524 m .
16. 660 Hz , 1100 Hz . In the same scale these are 330 Hz and 275 Hz or (E and $C\#$).
18. $l = 0.795 \text{ m}$, $f_1 = 440 \text{ Hz}$, $f_2 = 1320 \text{ Hz}$.

Chapter 12.

1. $6.0 \times 10^{14} \text{ Hz}$, this differs from the estimate of Ch. 6; q. 4, by a factor of 10, we could say that they agree to about an order of magnitude.
3. $5.0 \times 10^{-7} \text{ m}$ or 500 nm . For water, 376 nm ; for the glass 323 nm .
- 6.



10. $1.33 \sin \theta_{\text{water}} = \sin \theta_{\text{air}}$, when $\theta_{\text{water}} = 48.8^\circ$, $\theta_{\text{air}} \rightarrow 90^\circ$, after this the refracting ray reflects back into the water.
11. Sunlight reflected from water is partly (or wholly) polarised, sunglasses with their lens properly set will cut out all of the polarised reflection.
12. Maxima, $\theta_2 - \theta_1 = 12.0^\circ$. Minimum $\theta_0 = 5.7^\circ$.
14. Maxima, 1.2° , 2.3° and 3.5° . Minimum 2.9° .