ANSWERS

Topic 1 Physical Quantities & Units

Units

1. **E** 2. **D** 3. **C** 4. **C** 5. **D**
6. **D** 7. **C** 8. **A** 9. **B** 10. **D**
11. **A** 12. **D** 13. **B** 14. **A** 15. **B**
16. **C**

18. Nm 19. 1400 N

20. J, Jm^{-3}, As, VA^{-1}. 21. Pa

22. (b) kg m^2 s^{-2}; (c) kg s^{-1}; (d) 5.4%.

23. (a) ✗, ✓, ✗, ✓;
(b) 10^2 N, 10^3 W, 10^5 W, 10^3 Ω, 10^{-7} m.

24. (c)(i)(1) kg m^{-3}; (ii) ms^{-1}

25. Equation (b); 9.41 mm s^{-1}.

26. (b)(ii) kg m s^{-2}, As, A^2 s^4 m^{-3} kg^{-1}; $\varepsilon_o\mu_o = c^{-2}$.

27. Both are.

Avogadro Constant

29. **B** 30. **A**

31. (a)(ii) 1.99×10^{-26} kg; (c)(i) 6.8×10^{23} atoms;
(ii) 1.2×10^{-29} m^3; (iii) 2×10^{-10} m.

Scalars & Vectors

32. **D** 33. **A** 34. **C** 35. **C** 36. **A**
37. **D** 38. **B** 39. **B** 40. **C** 41. **D**

43. 0.68 N.

44. (b)(ii)(1) 2.5 ms^{-1}; (2) 4.3 ms^{-1}.

45. (a)(ii) 202 N.

48. (c)(ii) 5 ms^{-1}; (iii) 39 ms^{-1}.

Topic 2 Measurement Techniques

1. **E** 2. **D** 3. **E** 4. **B** 5. **D**
6. **D** 7. **E** 8. **D** 9. **E** 10. **C**
11. **D** 12. **E** 13. **D** 14. **D** 15. **B**
16. **C** 17. **C** 18. **B** 19. **D** 20. **D**
21. **B** 22. **C** 23. **D**

25. (0.028 ± 0.003) mm^2.

27. (a) 0.00337; (b) 0.337%;
(c) $(6.21\pm0.05)\times10^4$ mm^2.

28. (a)(i) 4.92 mm. 29. (b) ±16%.

30. (a)(i) 21.14 cm, 20.98 cm;
(ii) ±0.005 cm or 0.01 cm; (iii) ±12.5% or 25%.

31. (a) 2.0 V, 3.3 mA; (d)(i) ±3%; (ii) (610 ± 20) Ω.

33. (c)(i) (1.71 ± 0.04) Ω; (ii) $(5.2\pm0.5)\times10^{-7}$ Ωm.

Cathode Ray Oscilloscope (Measurements)

34. **B** 35. **B** 36. **E** 37. **D** 38. **C**
39. **B**

40. (c) 1.42 μs cm^{-1}.

Topic 3 Kinematics

Linear Motion

1. **C** 2. **D** 3. **D** 4. **D** 5. **B**
6. **A** 7. **A** 8. **E** 9. **C** 10. **A**
11. **B** 12. **B** 13. **C** 14. **C** 15. **B**
16. **B** 17. **D** 18. **B** 19. **C** 20. **C**
21. **A** 22. **C** 23. **D** 24. **D** 25. **D**

26. 2.9 m beyond stop line. 27. 0.166 s.

28. (a) 800 m; (b) 1.25 ms^{-2}; (c) 750 m;
(d) 5 s; (e) 1 km; (f) 90 m.

29. (b)(i) 2.71 s; (ii) 26.6 ms^{-1}.

30. (a)(i) 20 ms^{-1}; (ii) 2 ms^{-2}; (iii) −7 ms^{-2};
(iv) 300 m; (v) 250 m.

31. (b)(i) constant; (c)(i) 7.00 ms^{-1}; (ii) 0.0169 s.

33. (a) 15 ms^{-1}; (b) 11.3 m.

34. (b) 6.6 ms^{-2}; (c) 218 m; (e) 146 m.

35. (b) 0.40 ms^{-2}, 125 s; (c)(ii) 216.6 s.

37. (b)(ii)(1) 3.5 ms^{-2}; (2) 2.52 m; (3) 133 N.

38. (a)(i) 0.2 s;
(b)(i) 9.85 ms^{-1}; (ii) 10 ms^{-2}; (iii) 39.4 m.

Projectile Motion

42. **E** 43. **C** 44. **D** 45. **C** 46. **B**
47. **D** 48. **D** 49. **A** 50. **C** 51. **B**
52. **C** 53. **D**

54. *E*/4.

55. (a)(ii) 7.5 ms^{-1}; (iii) 13 ms^{-1}; (c) 8.6 m.

57. (a)(iii)(1) 12.1 ms^{-1}; (2) 7.0 ms^{-1};
(b) 0.714 s; (c) 10.

58. (c)(i)(1) $d = v\cos\theta\, t$; (2) $t = \frac{2v\sin\theta}{g}$;
(ii) 32.1°; (iii) smaller.

60. (b)(ii) 4.2 ms^{-1}; (iii) 40 m; (iv)(1) 1.63 ms^{-2};
(2) 3.27 J; (c) 12.2 ms^{-1}, 69.8° below horizontal

61. (b)(i)(1) 13.0 ms^{-1}; (2) 7.5 ms^{-1};
(ii)(1) 8.6 m; (2) 2.65 s; (3) 19.9 m.

Topic 4 Dynamics

Newton's Laws of Motion

1. **C** 2. **D** 3. **B** 4. **B** 5. **E**
6. **E** 7. **C** 8. **C** 9. **B** 10. **C**
11. **E** 12. **C** 13. **D** 14. **B** 15. **C**
16. **A** 17. **D** 18. **C** 19. **C** 20. **D**
21. **C** 22. **E** 23. **D** 24. **E** 25. **C**
26. **B** 27. **D** 28. **D** 29. **C** 30. **D**
31. **D** 32. **B**

33. 1.85×10^{4} N. 34. 0.11 Pa.

36. 30 N. 38. 55 N. 39. 168 N.

40. (b)(i) 15.4 kN; (ii) 4.81×10^{5} ms^{-2};
(c) 16 kg m s^{-1}; (d) 8.64 kg m s^{-1}.

41. (a) 60 000 kg m s^{-1}, 40 000 kg m s^{-1},
600 kJ, 800 kJ;
(b)(i) 3.0 s, 2.0 s; (ii) 30 m, 40 m.

42. (a)(i) 12.7 N; (ii) 3.72 N; (iii) 0.40 s.
(b)(ii) 0.52 s.

44. 30 ms^{-1}. 45. (c)(ii) 11.5 ms; (iii) 51.2 s^{-1}.

46. (d)(i) 1.5 MJ; (ii) 100 kN; (iii) 60 s.

47. (a)(i) 45000 Ns; (ii) 22500 Ns;
(iii) 675 kJ, 169 kJ; (iv) 4.5 kN; (v) 3.0 ms^{-2}.

48. (c)(i) 6.86×10^{4} ms^{-2}; (ii) 6.55 MPa;
(iii) 319 kW.

49. (c)(i) 1.6×10^{7} kg m s^{-1}; (ii) 0.30 s;
(iii) 53.3 MN; (iv) 2.67×10^{4} ms^{-2}.

51. (c) 0.064 kg, 37.5 ms^{-1}; (d)(i) 0.040 s;
(ii) 0.75 m; (e)(i) 3.6 Ns; (ii) 56.25 ms^{-1};
(f) 56.25 J, 562.5 W

52. (b)(i)(1) 11 ms^{-1}; (2) 0.68 ms^{-2}; (3) 217 m;
(ii)(1) 52.7 N; (2) 37.3 N; (iii) 90 N;
(d)(i) 155 N.

Conservation of Linear Momentum

53. **D** 54. **A** 55. **A** 56. **A** 57. **E**
58. **A** 59. **C** 60. **D** 61. **A** 62. **C**
63. **D** 64. **B** 65. **C** 66. **D** 67. **C**
68. **D** 69. **A** 70. **C** 71. **C**

73. (a) $u/2$; (b) 1/2.

75. (c)(i) 1.6 kg m s^{-1}; (ii) -5.5×10^{5} ms^{-1}.

76. (a)

collision	momentum	K.E.	T.E
elastic	✓	✓	✓
inelastic	✓		✓

(b)(i)(1) inelastic; (2) 6.0×10^{7} ms^{-1};
(ii) 4.06×10^{6} ms^{-1}.

78. (a) $\frac{M\sqrt{2gh}}{gT}$, $\frac{M(\sqrt{2gh}+gT)}{gT}$, M.

79. 122. 81. (b) 0.14 kg m s^{-1}; (e) 0.10.

82. (a)(ii) $\frac{4Mm}{(M+m)^2}$; (iii) 0.077.

84. Common velocity = $\frac{1}{2}u$,
kinetic energy at $t_o = \frac{1}{4}mu^2$,
kinetic energy at $t_s = \frac{1}{2}mu^2$.

85. (b)(i) 0.716; (ii) 42. 87. (b)(ii) 1.

88. (b)(ii) $v_2 = u$, $v_1 = 0$; (c)(ii) 1.37×10^{-13} J.

89. (c)(i) $^{224}_{88}Ra \rightarrow {}^{4}_{2}He + {}^{220}_{86}Rn$; (iii) 3.1×10^{7} ms^{-1}.

90. (c)(i) 2285 ms^{-1}; (iii) 136 ms^{-1}, 2420 ms^{-1}.

Topic 5 Forces

Hooke's Law

1. **A** 2. **E** 3. **C** 4. **C** 5. **C**
6. **B** 7. **D** 8. **C** 9. **A** 10. **A**

11. 11.25 J; 18.8 m. 12. 1.2 J.

13. (a) A: 0.1 m, B: 0.2 m; (b) 2 Nm^{-1}.

14. (b) 0.20 J.

15. (b) 3.5 m; (c) 7.8 kJ; (d) 7.9 m.

16. (a) MT^{-2}; (c) $K' = 2K$;
(d) $\frac{1}{2}K'x_1^2$; (i) 0.98 J; (ii) 0.49 J.

17. (c)(i) 2.8%; (ii) (92±3) Nm^{-1}; (d) 4.6%.

18. (c)(ii) 5.0 mm.

19. (b)(i)(1) 6.72 ms^{-1}; (2) 17.5 J;
(ii)(1) 1.33×10^{-3}; (2) 17.5 J; (3) 10900 N;
(4) 21800 N; (5) 1.97×10^{11} Pa.

20. (d)(i) 3.8×10^{-3} kg; (iii)(1) 0.192 J; (2) 3.84 J;
(v) 2.25 K.

21. (a)(i)(1) $k = \frac{W}{e}$.

Forces

22. A	23. C	24. A	25. D	26. D
27. E	28. D	29. C	30. B	31. A
32. B	33. D	34. D	35. D	36. C
37. C				

38. (a) 90 N; (b) 3 mm.

40. P_A = 540 Pa below atmosphere;
P_B = 180 Pa above atmosphere.

42. (a) 22.6 N; (b)(ii) 23.2 ms^{-1}; (c) 7.18 ms^{-2}.

43. (c)(i) 598 N; (ii) 598 N; (iii) 0.0739 kgm^{-1};
(d)(i) 46.2 N.

44. (c)(i) 657 N; (d)(ii) 420 N.

47. 1 mmHg = 133 Pa.

50. (a)(i) 1.6 cm; (b)(i) 0.480 N; (ii) 4.29 Nm^{-1};
(iii) 0.0686 N; (c)(i) 0.494 ms^{-1}; (ii) 0.573 s.

Equilibrium

51. C	52. C	53. E	54. B	55. B
56. C	57. E	58. C	59. A	60. A
61. B	62. D	63. A	64. A	65. C
66. B	67. C	68. C	69. D	70. A

76. (c) zero; (d) 500 N; (e) 15 kW.

77. (a) 72 Nm; (b) 900 N; (c)(ii) 1080 N, left.

78. (c) 15.0 kN. 79. (d)(ii) 420 N.

80. (b)(iii)(1) 0.10 Nm; (2) 0.70 Nm; (3) 3.0 Nm;
(iv) 38 N.

81. (d)(ii) 9.7×10^7 kg. 82. (c)(i) 1.36 kN.

83. (b)(i)(1) 2.07 cm; (ii)(1) 0.124 J; (2) 4.75 ms^{-1};
(3) 4.11 ms^{-1}; (iii)(1) 0.0975 kg ms^{-1}; (2) 0.65 N.

Topic 6 Work, Energy, Power

1. D	2. C	3. D	4. A	5. B
6. E	7. C	8. A	9. D	10. E
11. A	12. C	13. E	14. E	15. B
16. C	17. E	18. A	19. B	20. E
21. A	22. C	23. D	24. B	25. B
26. B	27. A	28. B	29. C	

30. 6.0 s.

32. (b)(i) 54 kg m s^{-2}; (ii) 54 N; (iii) 162 Js^{-1};
(iv) 362 Js^{-1}; (v) 524 W.

36. (c) 4.13 m; (d)(i) 10.1 J; (ii) 8.83 J;
(iii) 1.31 J; (iv) 4.67 ms^{-1}.

37. (c)(i) 10.1 kJ; (ii) 3.53 kJ; (iii) 17.4 ms^{-1};
(d)(i) 16 N.

38. (c)(i) kg m^{-1}; (ii) 36.6 kW;
(d)(i) 3.46×10^5 J; (ii) 1.18 kN; (iii) 1.10×10^7 J.

Topic 7 Circular Motion

1. B	2. D	3. B	4. D	5. C
6. C	7. C	8. B	9. A	10. D
11. A	12. A	13. D	14. B	15. A
16. C	17. A	18. B	19. B	20. D
21. D	22. D	23. D	24. D	25. B
26. B	27. C	28. C		

29. (c) $\sqrt{\frac{T_{max} - mg}{mr}}$ 30. 0.10 rad s^{-1}.

31. (a) 7.3×10^{-5} rad s^{-1}; (b) 470 ms^{-1}.
(c) 3.4×10^{-2} ms^{-2}.

32. (b) $\sqrt{5gL}$.

33. +9.1% (as percentage of indicated speed), or
+10% (as percentage of actual speed).

34. $\frac{g\sqrt{L^2 - W^2}}{W}$. 35. 1.82.

36. (a) 3.92×10^5 N; (b) 4.79×10^5 N;
(c) 2.74×10^5 N; (d) 6.86 ms^{-2}; (e) 9.11 km.

37. (a) 0.13 rad s^{-1};
(b) 2.7×10^5 N towards centre of circle.

38. (i) 1.62 ms^{-2}; (iii) 9.38°.

39. (a) 6.9×10^{-8}; (b) -6.9×10^{-8}.

41. (b) 351 ms^{-2}; 1.90×10^{5} ms^{-2}; (d) 137 kN.

42. (b)(i) 1.50 rad s^{-1}; (ii) 12.0 ms^{-1}; (iii) 18 ms^{-2};
(c)(iii) 1440 N; (v) 2220 N.

43. (c)(i)(1) 20.6 ms^{-2}; (2) 648 N;
(ii)(1) 8240 J; (2) 20.5 ms^{-1}.

44. (c) 1.36×10^{-8} N;
(d)(i) 1.49×10^{22} ms^{-2}; (ii) 6.5×10^{-11} m;
(iii) 9.8×10^{5} ms^{-1}; (iv) 4.15×10^{-16} s.

Topic 8 Gravitation

1. A	2. B	3. E	4. C	5. D
6. D	7. D	8. A	9. D	10. C
11. E	12. E	13. D	14. B	15. C
16. A	17. D	18. D	19. C	20. D
21. B	22. B	23. A	24. E	25. C
26. B	27. C	28. C	29. C	30. D
31. B	32. E	33. A	34. C	35. D
36. B	37. A	38. C	39. A	40. C
41. A	42. D	43. C	44. D	45. D
46. A	47. C	48. B		

49. 3.4×10^{8} m. 50. 5×10^{24} kg.

51. 2.4×10^{3} ms^{-1}. 52. 1.7 ms^{-2}.

53. 8.1 ms^{-2}.

54. (a) -6.3×10^{7} Jkg^{-1}; (b) -8.9×10^{8} Jkg^{-1}.

55. 1.24×10^{-2} M_E.

56. (a) 10 Nkg^{-1}; (b) 30 Jkg^{-1}; (c) 20 J; (d) 60 J.

57. 1680 ms^{-1}; 1.41×10^{6} Jkg^{-1}.

58. (i) 2580 MJ; (ii) 9.0 Nkg^{-1}.

59. (d) 7.82×10^{11} m.

60. (c)(i) 1.7 Nkg^{-1}; (ii) 3.5×10^{8} m.

61. (a)(ii) $g=\frac{Gm_1}{r^2}$; (iii) $F=\frac{Gm_1m_2}{r^2}$.

62. (b)(i) $r\omega$; (ii) $mr\omega^2$; (iii) $\frac{GMm}{r^2}$;
(c)(i) $\frac{2\pi}{\omega}$.

63. (b) 9.81 Nkg^{-1}; (d)(i) 1020 ms^{-1}; (ii) 2.72 mms^{-2};
(iii) 2.00×10^{20} N; (iv) 2.72×10^{-3} Nkg^{-1}.

64. (a) 9.83 N; (b) 9.83 N kg^{-1}; (d) 7860 J kg^{-1}.

65. 1.13×10^{4} ms^{-1}.

66. $A=5.5\times10^{-13}$ yr $km^{-3/2}$, $n=1.5$; $r_E=150\times10^{6}$ km.

67. +0.17%.

68. (a) 7.3×10^{-5} rad s^{-1}; (b) 4.2×10^{7} m;
(c)(i) 2.7×10^{9} J increase; (ii) 2.3×10^{8} J increase.

69. (b) 3.5×10^{5}.

70. $v_S=6.1\times10^{5}$ ms^{-1}; $v_M=2.4\times10^{3}$ ms^{-1}.

71. (a) B; (b) C; (c) D, E.

72. (c) $F_M=F_E$, $x/y=0.11$; (d) 2.3×10^{3} ms^{-1}.

73. (a) $T=-E$; (b) change in $T=\Delta E$ (increase),
change in $V=2\Delta E$ (decrease).

74. (b) 2.71×10^{-3} ms^{-2}.

75. (d) 3.91×10^{-4} N; (e) 2.65×10^{-4} N;
(f) $\pm3\times10^{-4}$ ms^{-2} or at least 5 s.f.

76. (a)(ii) 6.37×10^{6} m; (iii) 9.87 N; (b)(i) 2.77 mN;
(ii) 2.77×10^{5} ms^{-2}; (iii) 2.33×10^{6} s.

77. (b) 5.99×10^{24} kg; (c) 9.45 Nkg^{-1}; (f) 3.47 GJ.

78. (c)(i) 9.83 N; (ii) 0.0337 N; (iii) 9.80 N;
(d)(i) 9.83 ms^{-2}; (ii) 9.80 ms^{-2}.

79. (a) 0.19%; (b) 1.99×10^{20} N;
(c) 2.70×10^{-3} ms^{-2} towards centre of Earth.
(d) 2.65×10^{-6} rad s^{-1}, 2.37×10^{6} s; (f) 4.23×10^{7} m.

81. (b)(ii)(1) 7.27×10^{-5} rad s^{-1}; (2) 3.08 km s^{-1};
(3) 0.224 ms^{-2}; (4) 537 N; (5) 6.00×10^{24} kg.

82. (a)(ii) 1.99×10^{-7} rad s^{-1}; (b)(i)(1) 0.0662 N;
(2) 2.56 N; (iii)(1) 2.49 N towards the Sun;
(2) 5.87×10^{-3} ms^{-2}; (iv) 1.99×10^{-7} rad s^{-1}.

Topic 9 Temperature

1. C	2. C	3. A	4. C	5. E
6. C	7. C	8. B	9. E	10. B
11. E	12. A	13. E	14. D	15. A
16. B	17. A	18. B	19. D	20. B
21. E	22. E	23. B	24. D	25. D
26. D	27. B	28. D		

29. 55°C. 30. −183°C. 31. 37.8°; 0.2°.

34. (c)(i) platinum resistance; (ii) optical pyrometer.

39. (b)(i) 68.8°.

40. (b)(ii) $R_i=30$ kΩ, $R_s=0.5$ kΩ; 88°C; 50°C.

41. (e) 3.64×10^{-3} °C^{-1}. 42. (c)(i) 79.3°C.

44. (c)(iv) −0.15°C.

Topic 10 Ideal Gases

1. B	2. E	3. A	4. A	5. C
6. A	7. A	8. C	9. E	10. A
11. D	12. D	13. B	14. B	15. E
16. C	17. C	18. D	19. D	20. D
21. C	22. C	23. D	24. E	25. C
26. D	27. A	28. C	29. C	30. E
31. C	32. B	33. C	34. B	35. C
36. E	37. C	38. C	39. A	40. D
41. A	42. D	43. A	44. A	45. C
46. A				

47. 3×10^{-9} m. 48. 1.1×10^{5} Pa.

49. 2.5×10^{22}. 50. 0.024 m^3; 0.9995.

51. (a) $T' = T/2$; (b) $P' = P$.

53. 3.6×10^{5} ms^{-1}. 54. 1.0.

55. (a) 2.4×10^{-2} m^3; (b) 2.0×10^{-4}.

56. 2.5×10^{13} m^{-3}.

57. 1.04×10^{-20} J; 2500 ms^{-1} for hydrogen; 620 ms^{-1} for oxygen.

58. (i) 496.4 K.

59. (a)(ii) Nm^{-2}; (b)(i) 20.9 mol; (ii) 1.26×10^{25}; (c)(i) 7.24×10^{-30} m^3; (ii) 9.13×10^{-5} m^3.

60. (b) 291.3 K. 61. (c) 0.25 m from either end.

64. (c) 10 ms^{-1}.

67. Interatomic spacing in solids ~ 0.1 nm; in gases ~ 1 nm; rms speed increases by 1/600.

68. $T_{Ne} = 450$ K; $T_{Ar/Ne} = 450$ K; $\frac{v}{\sqrt{2}}$

69. (b)(iv) 7×10^{4} ms^{-1}; (v) 2×10^{5} K.

70. (d) $n = \frac{N_A p}{RT}$; 1.0×10^{14} molecules s^{-1}; 40 s.

71. (b)(iii) 1630 ms^{-1}. 72. (d)(iii) 1.62×10^{4} K.

73. (a)(i) 2.99×10^{-29} m^3; (ii) 5.01×10^{-26} m^3; (iii) 11.9.

74. (c)(ii) 490 ms^{-1}; (iv) 483 K.

76. (a)(i) 279 K; (ii) 2.87 mol; (iii) 1.88×10^{5} Pa.

78. (c)(i) 2.53×10^{5} Pa; (ii) 7.48×10^{5} cm^3; (d) 24.7 min.

80. (c)(i) 0.0225 m^3; (ii) 1.43 kg m^{-3}; (d)(ii) 464 ms^{-1}; (e)(i) 461 ms^{-1}; (ii) 5.65×10^{-21} J.

81. (c)(i)(1) 6.38×10^{-21} J; (2) 2.76×10^{3}.ms^{-1}; (ii) 1230 K.

83. (b)(ii) 494 ms^{-1}; (c)(iii) 694 K

Topic 11 Thermodynamics

1. D	2. E	3. D	4. D	5. A
6. C	7. D	8. E	9. B	10. D
11. A	12. E	13. C	14. D	15. D
16. B	17. D	18. B	19. B	20. C
21. A	22. B	23. D	24. E	25. C
26. C	27. D	28. E	29. D	30. E
31. D	32. D	33. E	34. A	35. E
36. D	37. D	38. C	39. A	40. A
41. C	42. D	43. D	44. D	45. B
46. E	47. B	48. B	49. C	50. B
51. B	52. D	53. D	54. B	55. C
56. B	57. B	58. A		

60. (a) 2.26 MJ; (b) 1.69×10^{5} J; (c) 2.09 MJ

62. 900 J. 63. 8990 J; 9.99×10^{-14} kg.

65. 38 J. 66. (i) 2400 W; (ii) 8000 W.

67. (b)(ii) 600 J decrease.

68. (a) 0.0201 mol; (b) 366 J; (c) zero; (d) 2.27×10^{5} Pa.

69. (a) 0.0116 mol; (b) 2.62 MPa; (c) 91 J.

70. (b)(i) 1.69 m^3; (ii) 171 kJ; (iii) 2.09 MJ; (iv) 2.09 MJ.

71. (a)

	increase in internal energy / J	*Heat supplied to gas* / J	*Work done on gas* / J
A to B	1200	0	1200
B to C	−1350	−1350	0
C to D	−600	0	−600
D to A	750	750	0

(b) 2.25.

72. (a)(ii) 2.76×10^{21} J. 73. (d) 2.09×10^{6} J.

74. (a)(i) 1840 W; (ii) 2.27×10^{6} J kg^{-1};

77. (a) 1.07×10^{3} J K^{-1} kg^{-1}.

78. (b) 25 J; (c) 88 J.

80. (c) 3.34×10^{25}; (d) 5×10^{-21} J.

81. (c) 0.16 mol; (e)(i) 2000 J; (ii) 2800 J;
(f) both 4000 J; (g) 800 J.

82. (b)(i) 2800 K, 2300 K;
(ii) 0, +300 J, +1840 J, −440 J, −1700 J;
(iv) 880 J; (v) 0.34.

83. (b) 96.9 g.

84. (d)(i) 4.75×10^{-3} m^3; (ii) 984 K;
(iii)(1) 29.1 J K^{-1} mol^{-1}; (2) 4.92×10^{-4} m^3;
(3) 1750 J; (4) increase of 4400 J.

87. (c)(i) 695 K; (ii)(1) 20.4 J mol^{-1} K^{-1},
(2) 1.29 MPa; (iii)(2) −62 J.

88. (e)(i) 51 J; (ii) 81 J; (iii) 54 J; (iv) 135 J.

89. (b)(ii) 8.33 A; (iv) 2.26×10^6 J kg^{-1};
(c) Assume volume of cup = 250 cm^3,
initial temperature = 30°C; expenditure = 313 p.

90. (c)(i) 4240 J; (ii) 0.056 K; (d)(i) 6.02×10^{26};
(ii) 7.04×10^{-24} J; (e)(i) 0.34 K.

91. (d) 3.36×10^5 J kg^{-1}; (e) 1.69×10^5 J;
(f) 2.26×10^6 J kg^{-1}.

92. (d) 774 J.

Topic 12 Oscillations

Simple Harmonic Motion

1. D	2. B	3. C	4. B	5. D
6. E	7. C	8. D	9. D	10. C
11. C	12. C	13. B	14. D	15. E
16. D	17. D	18. C	19. E	20. E
21. C	22. D	23. E	24. D	25. E
26. E	27. B	28. A	29. E	30. C
31. B	32. D	33. C	34. B	35. C
36. D	37. D	38. A	39. C	40. A
41. D	42. D	43. D	44. C	45. D
46. D				

47. (a) 0.026 ms^{-1}; (b) 0.014 ms^{-2};
P = 0.05 m, Q = π/6 rad.

48. *T*. 49. (a) 2.3 Hz; (b) top.

50. $T_1 = 2\pi\sqrt{\frac{m}{k}}$, $T_2 = \frac{T_1}{\sqrt{2}}$, $T_3 = \frac{T_1}{2}$.

51. (a) 2.3×10^4 ms^{-2}; (b) 30 ms^{-1}.

52. (a) 0.20 m; (b) 0.63 s; (c) 2.0 ms^{-1}.

53. (a) 0; (b) 0.44 ms^{-2}. 54. 6.2×10^{-4} m.

55. (a) 6.0 cm; (b) 5.1 cm. 57. 0.20 s.

60. (a) 1.5×10^{-3} J; (c) 40 mm.

61. (a) 1.2 N; (b)(i) 2.9 Hz; (c)(ii) 3.3 ms^{-2}.

62. (a) 50 Hz; (b) 100π rad s^{-1};
(c) x = (0.0030 m) sin [(100π rad s^{-1}) t];
(d)(i) 0.9 ms^{-1}; (e)(i) 0.0444 J.

63. (b)(i) 0.04 s; (ii) 25 Hz; (iii) 157 rad s^{-1};
(iv) 2.0 mm.

64. (a) 0.12 m; (b) 2 s; (c) 0.5 Hz;
(d) π rad s^{-1}; (e)(i) 0; (ii) $0.12\pi^2$ ms^{-2}.

65. (b)(i) 0.25 Hz; (ii) 1.57 rad s^{-1}; (iii) π/2 rad;
(c)(i) 1.43 s; (ii) 0.31%.

66. (c)(i) 20 cm; (ii) 1.80 s; (iii) 70 cm s^{-1};
(iv) 2.5 ms^{-2}.

68. 2.05 p.m. (1405 h). 69. $4\pi^2$ rad s^{-1}.

72. 0.61.

74. (a) 0.010 m; (b) 0.31 s; (c) 2.5×10^{-2} m;
(d) 16 Nm^{-1}.

75. (c) 0.82 m; (d)(ii) 99; (iii) 180 s.

77. (a)(ii) (13.6±0.6) h; (iii) 2 m;
(c)(i) 8.0 m; (ii) 2.0 m; (iii) 22800 s;
(iv) 0, 22800 s, 45600 s; (v) 12200 s.

78. (b)(ii)(1) 81.7 rad s^{-1}; (2) 1.47 mm.

Oscillations & Resonance

79. A 80. B 81. D 82. C 83. A
84. D

86. (b) 220 Hz, 440 Hz, ...

88. (b)(i) 3.0 Hz, 78.8 g.

89. (b)(i) 78.5 rad s^{-1}; (ii) 0.080 s.

90. (a)(i) 0.60 s; (ii) 10.5 rad s^{-1};
(b)(i) 0.20 s; (ii) $\frac{2\pi}{3}$ rad.

92. (a) $\frac{D}{4}\sqrt{\frac{\rho g}{\pi m}}$; (b) 7.1×10^{-2} m.

93. (a) $\frac{1}{2\pi}\sqrt{\frac{mg}{MS}}$; (b) $\frac{\lambda}{2\pi}\sqrt{\frac{mg}{MS}}$, 15.8 ms^{-1}.

96. 15 m. 100. (a)(ii)(2) 799 Nm^{-1}.

101. (b)(i) 0.11 m; (ii) 1.7 s; (iii) 0.59 Hz; (iv) 3.7 rad s^{-1}; (c)(i) 0 s; (ii) 1.28 s; (iii) 0.42 s; (iv) 0 s; (v) 0.42 s.

Topic 13 Waves

Waves

1. D	2. B	3. E	4. B	5. B
6. B	7. B	8. D	9. E	10. D
11. D	12. C	13. D	14. B	15. D
16. B	17. B	18. A	19. B	20. D
21. D	22. B	23. A	24. B	

25. (a) 4.0×10^{-7} Wm^{-2}; (b) 14 μm.

26. 6.0×10^{-8} m. 27. (b) 0.125 m.

29. (i) 100 Hz; (ii) 149.25 (149, to 3 s.f. justified by data); (iii) $\pi/2$ rad (unreliable, as (ii) is reliable to only 3 s.f.); (iv) 2×10^{-16} J.

30. 3.4×10^{-3}. 32. 1.5.
33. (b) 4A, 16I, 2A, 4I; (c)(i) 6 J; (ii) 6.4×10^{-5} Wm^{-2}; (iii) 2.0×10^{-15} Wm^{-2}.

34. (b)(i) 0.50 Pa; (ii) 1190 Hz; (iii) 0.29 m.

35. (b) 365 ms^{-1}.

38. (c)(i) 0.4 m; (ii) 800 Hz; (iii) 320 ms^{-1}; (iv) $\pi/2$ rad; (v) 4; (vi) 16.

Polarisation

41. E	42. A	43. C	44. E	45. D
46. E				

49. 45°. 50. 13%.

51. 60°, 3/4. 53. 28 μm.

Electromagnetic Spectrum

54. B	55. C	56. E	57. B	58. E
59. C	60. D	61. B	62. B	63. D
64. B	65. B	66. C	67. B	68. B
69. A	70. C			

Topic 14 Interference (Superposition)

1. B	2. D	3. A	4. E	5. E
6. B	7. A	8. D	9. D	10. E
11. E	12. B	13. A	14. E	15. D
16. E	17. C	18. D	19. B	20. D
21. A	22. B	23. B		

24. (a) 4×10^{-4} rad; (b) 4×10^{-2} rad.

26. (a) 0.5 mm. 27. (c)(i) 30.8.

30. 44. 34. (b)(iii) 1.0003.

36. (c) 1.84 mm.

Superposition

38. E 39. A 40. B

41. 5.8I.

42. (a)(i) 200 Hz; (b) $\frac{9}{4}$I; (c)(ii) I/4.

Topic 15 Stationary Waves

1. B	2. E	3. E	4. D	5. C
6. B	7. C	8. E	9. A	10. C
11. B	12. C	13. E	14. C	15. E
16. D	17. A	18. C	19. D	20. B
21. C	22. D	23. D		

24. (a) 1.67 m; (b) 360 ms^{-1}.

25. (a) 250 Hz, 750 Hz; (b) 0.33 m.

27. (a) 330 ms^{-1}; (b) 0.03 m.

28. $\frac{c}{2L}$, $\frac{c}{L}$. 29. 1.0×10^{10} Hz.

31. 375 Hz; 125 Hz, 250 Hz. 32. 600 ms^{-1}.

34. 250 Hz. 35. (b) 0.3 ms^{-1}

37. 200 Hz.

40. (b) 5950 Hz, 8330 Hz, ...; (c) 1.30×10^{11} Pa.

43. (b)(iii) 24 ms^{-1}. 45. (b)(ii)(2) 1.52 m.

Topic 16 Diffraction

Single-slit

1. A	2. B	3. D	4. D	5. E
6. E	7. A	8. C	9. D	

10. (a) 0.10 m and 10 m; (b) < 0.10 m.

Grating

19. A	20. B	21. A	22. A	23. D
24. A	25. D	26. C	27. A	28. A
29. B	30. B	31. E	32. B	33. B
34. C	35. D			

36. 2.4 μm. 37. 0.19°. 38. 433 nm.

39. ⩾ 22°. 40. (b) 591 nm.

41. (b) AB; (c) 0.21 rad; (d) 350 mm^{-1}.

42. 5.44×10^{-4} rad. 43. 17.1°, 3.14×10^{-4} rad.

44. 1st order blue, 19.6°; 1st order red, 36.0°;
2nd order blue, 42.2°; 2nd order, λ_{max} = 595 nm.

45. (c)(i) 640 nm.

46. (d)(i) λ_v = 450 nm, λ_r = 599 nm.

47. (d)(ii) 5.63×10^{-5} m. 48. (c)(i) 6.26×10^{-7} m.

49. (b)(i) 6.84×10^{-7} m. 50. (e)(ii) 0.110°.

Topic 17 Current Electricity

1. C	2. C	3. D	4. C	5. A
6. B	7. D	8. E	9. C	10. C
11. B	12. D	13. B	14. A	15. C
16. A	17. B	18. E	19. A	20. A
21. A	22. D	23. A	24. A	25. C
26. C	27. B	28. C	29. E	30. A
31. C	32. A	33. D	34. A	35. B
36. D	37. B	38. B	39. A	40. D
41. D				

42. (a) 1 Ω; (b) 20Ω, 0.05 Ω. 44. 9.6 mΩ.

45. 4.5×10^4 J; 1.2 Ks^{-1}. 46. 0.63 W.

49. 1.7 kW. 50. (a)(i) 0.25 A; (ii) 960 Ω.

51. (b) 45.6 mA. 52. (a) 0.33 A.

53. (d)(i) 2.00×10^4 s; (ii) 9.38×10^{14} s^{-1}.

54. 13.3 Ω.

58. E = 1.5 V, r = 2 Ω, R_1 = 4Ω, R_2 = 3 Ω;
(a) 0.28 W; (b) 0.56 W.

59. 0.5. 60. (a) 0.70 Ω.

61. E = 3.00 V, r = 52.5 Ω. 62. (b) 8.66 Ωm^{-1}.

64. (b)(i)(1) $\frac{E}{R+r}$; (2) $\frac{E^2R}{(R+r)^2}$;
(c)(i)(1) 0.095 Ω; (2) 0.128.

65. (a)(i) 16 C; (ii) 0.267 A; (iii) 33.7 Ω;
(c)(i) 3.00 Ω; (ii)(3) 3.07 Ω.

66. (c)(iii) 225 V; (iv) 7.5 A; (v) 1690 W.

68. (b)(i) 1.02 A; (ii) 8.49 V; (iii) 8.63 W.

71. (c) 0.344 Ω; (d)(i) 268 A;
(ii)(1) 10.3 Ω; (2) 2.31 kV;
(3) 4170 kW; (4) 0.926.

73. (c)(i) 2.50×10^{-4} Cs^{-1};
(ii) 3.04×10^{-5} Cs^{-1}; (iii) 9.50×10^{13} s^{-1};
(e)(i) out of paper; (iii) 1.6 mA.

74. (b) 22.3 C;
(d)(i) 13.0 A; (ii) 17.6 Ω; (iii) 1.50×10^7 J;
(e)(i) 3.0×10^5 Ω; (ii) 1.88 mA.

Topic 18 D.C. Circuits

1. A	2. A	3. C	4. B	5. A
6. E	7. C	8. A	9. A	10. B
11. B	12. A	13. C	14. B	15. C
16. C	17. A	18. D	19. B	20. C
21. D	22. C	23. C	24. A	25. B

26. (a) 3 Ω; (b) 300 Ω; (c) 0 Ω at 5 mA, 300 Ω at 2.5 mA, 900 Ω at 1.25 mA, 1200Ω at 1 mA.

27. (a) 26.4 V; (b) one of the 1000 Ω resistor.

28. 0.25 A. 29. (b)(i) 48 V; (ii) 14.4 Ω.

32. (b)(i) 30 Ω.

33.

circuit component	A	B	C	whole circuit
potential difference/V	12	10	2.0	12
current/A	3.0	2.0	2.0	5.0
power/W	36	20	4.0	60
resistance/Ω	4.0	5.0	1.0	2.4

34. (a) $\frac{VRR_1}{RR_1+RR_2+R_1R_2}$;
(b) $\frac{VRR_2}{RR_1+RR_2+R_1R_2}$; Both are 0.5 V.

35. 4×10^{-3} Ω.

36. I_a = 0.52 A, I_b = 0.36 A, $I_c = I_d$ = 0.25 A.

37. (c)(i) 2.0 V; (ii) 1.0 V; (iii) 0.67 V.

38. (b)(ii) 4.4 Ω; (iii) 4.0 Ω; (iv) 1.1 Ω.

39. (b)(i) 0.25 A; (ii) 20 V; (iii) 80 Ω;
In parallel: 0.021 A, 240 V, 11500 Ω;
(d)(i) 0.19.

40. (b)(ii) 3.32 V, 8.68 V; (c)(ii) 10.2 kΩ;
(d) 3.86 V, 8.14 V.

41. (b)(i) 0.20 A; (ii) 0.13 A.

42. (b)(i) 78.4 Ω; (ii) 797 W;
(c) 797 W, 399 W, 1594 W; (d)(i) 28.3 W.

43. (c)(i) 1.00 V; (ii) 1.03 V.

44. (e)(i) 50 mA; (ii) 6.0 V; (iii) 75 Ω.

45. (c)(i) 6.0 A; (ii) 7200 C;
(iii) 86400 W; (iv) 2.0 Ω;
(d)(i)(1) 12 A; (2) 0.25 Ω; (ii) 12 A.

46. (d)(i)(1) 50 Ω; (2) ∞; (iii)(1) 60 mA.

47. (c)(i) $I_1 = I_2 + I$; (ii) $E_1 = I_1R_1 + IR_2$;
(iii) $E_2 = -IR_2$.

Potential Divider

48. E 49. A 50. B 51. C 52. E
53. D 54. C 55. D 56. B 57. D
58. B 59. D 60. B
61. 4.7×10^{-7} Ωm.

62. (c)(ii)(1) 1.25 kΩ; (2) 7.19 V.

63. (c)(ii)(1) 2.00 Ω; (2) −0.01 V.

Potentiometer

64. A 65. D 66. D 67. B 68. B
69. D 70. E 71. C

72. 4000 Ω.

74. (i) 75 cm; (ii) 90 cm; (iii) 75 cm;
(iv) 41.7 cm

75. (i) 36 Ω; (ii) 250 Ω.

76. (d)(i) 1.7 Vm^{-1}; (ii) 0.21 A; (iii) 1.4 Ω.

Topic 19 Electric Field

1. D 2. C 3. C 4. C 5. B
6. E 7. C 8. A 9. E 10. C
11. A 12. B 13. B 14. E 15. D
16. D 17. E 18. B 19. E 20. D
21. C 22. C 23. D 24. C 25. B
26. B 27. D 28. C 29. D 30. B
31. A 32. B 33. A 34. A 35. A
36. B 37. D 38. D 39. B 40. A
41. D 42. C 43. D 44. C

45. (a) 5×10^{8} J; (b) 1.9×10^{9} ms^{-1}.

46. 1.8×10^{5} V. 47 (a) −Q; (b) +Q.

48. 4.6×10^{21} Vm^{-1}. 49. 100 N; 1.5×10^{-13} J.

50. 3×10^{24} Vm^{-1}. 52. 1.2×10^{36}.

57. (a) 8.9×10^{-10} N.

58. (b)(ii) $E = \frac{Q_1}{4\pi\varepsilon_o r^2}$; (iii) $F = \frac{Q_1Q_2}{4\pi\varepsilon_o r^2}$.

59. (b)(i) 1.26×10^{-17} C; (ii)(1) 4.55×10^{4} V;
(2) 1.45×10^{-4} J; (c) $E_T = E_G + E_E$

60. (b)(iii)(1) β/4; (2) β/2.

62. 5.56. 63. 3.95×10^{-8} C. 64. $V = \frac{10^5}{T}$

66. (a) 8.7×10^{6} ms^{-1} in direction −Oy;
(b) 4.3×10^{13} ms^{-1} in direction −Oy;
(c) 244 Vm^{-1} in direction +Oy.

67. (a) $\omega = \sqrt{\frac{e^2}{4\pi\varepsilon_o m_e r^3}}$. 68. 150 C.

69. (a) 1.33×10^{-5} C; (b) 6.7×10^{-6} A; (c) 2 W.

70. (a)(i) −Cx; (ii) −Cy; (iii) 0, $\frac{-2Gm}{r}$.

71. (i) $4\pi\varepsilon_o rV$; (ii) $\frac{V^2 4\pi\varepsilon_o r}{x}$; (iii) $\frac{V^2 4\pi\varepsilon_o r}{xm}$;
(iv) $\frac{x}{V}\sqrt{\frac{m}{2\pi\varepsilon_o r}}$.

72. 2.2×10^{-13} m.

73. (d)(i) 1.3×10^{-5} C; (ii) 6.0×10^{5} V.

74. (b) 4.32×10^{-14} N; (c)(i) 3.37×10^{-16} J;
(ii) 3.37×10^{-16} J; (iii) 2.11 kV, A;
(d)(i) 100 V; (ii) 1.6×10^{-17} J.

75. (c)(i) 4.16×10^{42}.

76. (b)(ii) 15 cm; (c)(i) 3.17 μC; (ii) 16.7 pF.

77. (e)(i) 1.97×10^{-13} J.

78. (b)(i) 140 Vm^{-1}; (ii) 1.21×10^{6} ms^{-1};
(c) same.

Topic 20 Capacitance

1. B 2. D 3. C 4. D 5. C
6. B 7. A 8. D 9. C 10. E
11. B 12. A 13. D 14. B 15. C
16. D 17. A 18. A 19. D 20. D
21. B 22. B 23. B 24. A 25. C
26. A 27. C 28. C 29. D

30. (a) 1.25×10^{-2} J; (b) 5×10^{-5} J; (c) 2.5×10^{-2} J;
(d) 1.25×10^{-2} J.

31. (a) 1×10^{-7} C; (b) 1 kV; (c) 4×10^{-5} J.

32. (a) $C_oV_o^2$; (b)(i) $\frac{8}{5}V_o$; (ii) $\frac{3}{5}C_oV_o^2$.

33. 7 nF

35. (b)(i) 200 μC; (ii) 4 mJ; (iii) 2 mJ.

36. (a) 0.99 nC; (b)(ii) 35 nA.

37. (a) 1.32 mC; (b) 3.96 mJ.

38. (a)(ii) 0.002 C; (iii) 0.002 C; (iv) 0.020 J.

39. (a)(i) 6.0×10^{-3} C; (ii) 0.090 J; (c) 0.060 J.

41. 2.16×10^{5} J, 2×10^{2} J. 42. 2×10^{-2} J.

44. (i) 3.0 nC; (ii) 850 s. 45. 7 ms.

46. 5.6 N.

48. (a) 1.2×10^{-8} C; (b) 6.0×10^{-7} J; (c) 70 pF; (d) 1.0 μJ.

52. (b)(i) 12.0 s; (ii) 28.8 mJ; (c)(i) 15.0 μF; (ii) 360 μC; (iii) 360 μC; (iv) 7.66 V.

53. (b)(i)(1) 50 μF; (iv)(1) 4.59 J; (2) 164 V.

Topic 21 Electromagnetism

Magnetic fields due to currents

1. D	2. E	3. B	4. B	5. D
6. A	7. C	8. A	9. A	10. A

11. $2B$.

Force on a current-carrying conductor

21. B	22. D	23. D	24. D	25. E
26. B	27. D	28. D	29. A	30. B
31. D	32. A			

34. few × 10^{-6} N.

36. (c)(i) 3.08 mT; (ii) 5.39×10^{-4} N; . (iii) 8.24 cm.

37. (c)(i) 0.0225 m^3; (ii) 1.42 kg m^{-3};
(d)(ii) 464 ms^{-1};
(e)(i) 461 ms^{-1}; (ii) 5.65×10^{-21} J.

39. 2.5 NA^{-1}, 1.0 N; 0.637 T; 1.5 mC.

40. 4.8 μT. 41. $B=\dfrac{\sqrt{T_1^2+T_2^2}}{abIN}$

43. (a) x; (b) $x/2$. 44. (b)(ii) 1.0 cm.

Force between parallel conductors

47. B	48. E	49. D	50. E	51. A
52. A	53. A	54. C	55. C	56. C
57. C	58. C	59. B		

62. (c)(ii) $\dfrac{F}{\ell}=\dfrac{\mu_oI_1I_2}{2\pi r}$.

64. 30 A wire: 1.0 mN, towards west,
20 A wire: zero force.
65. 5.0×10^{-5} N. 67. (c)(i) 1.33 mN.

Hall Effect

68. D

73. 2.14×10^{22} m^{-3}.

Topic 22 Electromagnetic Induction

1. E	2. D	3. D	4. A	5. E
6. A	7. A	8. D	9. A	10. E
11. E	12. D	13. D	14. A	15. B
16. D	17. E	18. A	19. D	20. D
21. B	22. D	23. B	24. C	

25. (a)(i) 3.1×10^{-5} V; (ii) 2.2×10^{-5} V.

26. (a) 2.5×10^{-3} Wb; (b) 2.5×10^{-5} C.

27. 100 Hz. 28. 1.2×10^{-2} T.

39. $E=\mu_onIAf$; $R=100\mu_onAf$.

40. (a) 50 mV; (b) 10^{-2} Wb; (iii) 1.2×10^{-2} Wb.

41. 1.4 A. 42. 8.66×10^{-5} C; 1.23×10^{-4} Ks^{-1}.

43. 12.6 rev s^{-1}.

47. (b) 8.66 Ωm^{-1}; (c)(i) 3260 Ω; (ii) 4.62×10^{-5} T.

50. (d)(i) 1.11 ms; (ii) 16.7 rev s^{-1} or 13.6 rev s^{-1}.

Topic 23 Alternating Currents

1. A	2. C	3. B	4. C	5. C
6. C	7. E	8. D	9. D	10. C
11. D	12. D	13. C	14. D	15. D
16. C	17. B	18. D	19. A	20. D
21. A	22. C	23. A	24. A	25. B
26. D	27. C	28. C		

29. (a) 7.1 V; (b) 0 V.

32. (a) 10 A; (b) 7.1 A; (c) 25 Hz; (d) 135°.

33. (a) 1.0 A; (b) 2.0 A; (c) 2.0 A.

34. $< I > = 0$; $< I^2 > = \frac{1}{2} I_o^2$.

35. (a) 1.41 V; (b) 667 Hz. 36. 1/2.

37. (a) 30 Ω; (b) 1900 W; (c) 3800 W.

38. (a)(i) 180 W; (ii) 180 W.

40. (b)(i) 180 V; (ii) 27 W; (iii) 4.5 A; (iv) 0.15 A.

42. (a)(i) 50 Hz; (ii) 3 A; (iii) 2.12 A; (b) 45 W; (c) 0.15 A.

43. (a) 400 A; (b)(i) T: 25, U: 1/25; (ii) 16 A_{ms}; (d)(ii) 566 A.

47. (a)(i) 5 ms; (ii) 200 Hz; (iii) 11.4 V; (iv) 8.0 V; (c) 56 V; (d) 630 μF.

48. (c)(i) 600 V; (ii) 25.2 W; (iii) 50.4 W; (iv) 1.4 mA.

Rectification

49. **A** 50. **D** 51. **B** 52. **C** 53. **E**
54. **B** 55. **A** 56. **D**

59. 9.0×10^{-4} J.

62. (a)(ii) B, D; (b)(i) 1/20; (ii) 17 V.

63. (a) 5.0 Vcm^{-1}. 64. (a)(i) 9.2 V; (ii) 13.0 V.

65. (a) peak; (b) 4.7 V. 66. 0.9 W.

67. 0.644.

Topic 24 Analogue Electronics

1. **C** 2. **E** 3. **C** 4. **D** 5. **E**
6. **D** 7. **B** 8. **D**

9. $R_1 = 40$ kΩ, $R_2 = 50$ kΩ. 10. –0.9 V.

13. –4.0 V.

14. (a) 0 V; (b)(i) 1.0 μA; (ii) 1.3 μA; (iii) 2.3 μA; (c) 0.14 V.

15. (a)(i) –50; (ii) 9 V.

16. (a) –10; (b) 5.0 V; (c)(i) 0.71 V; (ii) ±6.0 V.

17. (a)(i) 40; (ii) 1.7 kΩ.

19. $R_3 = 2.5$ kΩ, $R_4 = 20$ kΩ. 21. (d)(ii) 2.9 ms.

22. (d)(i) 0 V; (ii) 0.03 V; (iii) 0.3 V.

24. (a)(i) 0 V; (ii) 0 A; (iii) ±9 V; (b)(i) 0.30 mA; (ii) 0.20 mA; (iii) 0.20 mA; (iv) –9 V.

26. (a)(ii)(1) 10^4 Hz; (2) 2.0 V.

27. (d)(i) –3.86 V.

28. (a)(i) inverting; (ii) 45.

30. (a)(ii)(1) –1.0 V; (2) 9.0 V.

31. (b)(ii) –100.

Topic 25 Charged Particles

In B Field

1. **C** 2. **E** 3. **B** 4. **E** 5. **A**
6. **E** 7. **A** 8. **C** 9. **A** 10. **A**
11. **E** 12. **C**

13. (a) 3.6 ns; (b) 3.6 ns. 15. 2.61 mT.

16. (d) $\frac{Mv}{BQ}$. 17. 5.1×10^7 ms^{-1}.

18. 2.1×10^7 ms^{-1}.

20. (a) 0.76 m; (b) 1.14 μs; (c) 5.6×10^6 ms^{-1}; (d) 6.4 m; 8.0 m.

21. (c) $\sqrt{\frac{2Ve}{m}}$; (d) $\frac{2V}{B^2 r^2}$;
For proton: reverse polarity & reduce V by 1840 factor.

22. 1830. 23. (b)(i) 0.23.

24. (b)(ii) $\sqrt{\frac{2MV}{B^2 Q}}$.

In E Field

25. **D** 26. **D** 27. **B** 28. **D** 29. **D**
30. **A** 31. **B** 32. **B** 33. **C**

34. 1.2 ns. 35. $\sqrt{2}$. 36. $\frac{v}{\sqrt{2}}$.

37. (b)(i) 50 kVm^{-1}; (ii) 8×10^{-15} N.

38. (a)(i) 8800 V; (ii) 1.41×10^{-15} J; (iii) 1.41×10^{-15} J; (iv) 5.56×10^7 ms^{-1}.

39. (a) 2.1×10^{-17} J; (b) 5.8×10^6 ms^{-1} at 60^0 to PQ.

40. 2.5 kV.

41. (a) 5.57×10^{6} ms^{-1} at 90° to PQ;
(b) 2.69 ns, 2.09×10^{15} ms^{-2} at 90° to PQ;
(c) 238 V.

42. 1.25×10^{14} ions/sec; 3×10^{-5} s.

43. (b)(i) 1.32×10^{15} ms^{-1} downwards;
(ii) 8.1×10^{6} ms^{-1}.

44. (b) 7.0×10^{14} ms^{-2} upwards;
(c) $v_v = 2.8\times10^{6}$ ms^{-1}, $v_h = 1.5\times10^{7}$ ms^{-1};
(d) 10.6°.

45. (c)(i) 10.2 ns.

46. (b)(i) 6.45×10^{-10} s; (ii) 1.6×10^{4} Vm^{-1};
(iii) 2.56×10^{-15} N; (iv) 2.81×10^{15} ms^{-2};
(v) 1.81×10^{6} ms^{-1}; (c) 0.88 cm.

In B & E Fields

47. A	48. E	49. A	50. A	51. C
52. D	53. E	54. B	55. B	56. C
57. B	58. D			

59. $v = \dfrac{E}{B}$. 61. 3.49×10^{7} ms^{-1}.

62. (b) $\dfrac{E}{B}$.

68. (c)(i) 1.64×10^{-26} N; (ii) 2.72×10^{-13} N;
(iii) 1.22×10^{-13} N;
(f)(i) 2.98×10^{-13} N; (ii) 1.79×10^{14} ms^{-2}.

69. (b) $F = BQv$;
(d)(i) 1.84×10^{5} ms^{-1}; (ii) 1.53×10^{5} Vm^{-1}.

70. (d)(i) 3.04×10^{-14} J; (e)(i) 0.348 m.

71. (b)(i) 2.70×10^{4} Vm^{-1}; (ii) 3.2×10^{-16} J;
(iii) 2.65×10^{7} ms^{-1};
(c)(ii) 2.85 cm; (iii) 3.70×10^{5} Vm^{-1}.

72. (a)(iii) gravitational; (b)(i) 5.59×10^{-11} NC^{-1};
(c)(i) 1.6×10^{-19} C; (ii) 3.32×10^{-26} kg;
(d)(ii) 1.16×10^{5} ms^{-1}; (iii) 0.0534 T.

Millikan's Experiment

73. E	74. A	75. D	76. A	77. E
78. C	79. E	80. B	81. A	82. E
83. B	84. D	85. B	86. A	

89. 1.61×10^{-19} C. 90. 1.6×10^{-19} C.

92. $+3.45\times10^{-20}$ C.

93. 4.92×10^{-10} e.s.u.; 1 e.s.u. = 3.25×10^{-10} C.

Topic 26 Quantum Physics

Photoelectricity

1. E	2. E	3. D	4. B	5. D
6. C	7. D	8. C	9. A	10. E
11. A	12. C	13. A	14. E	15. C
16. A	17. B	18. B	19. B	20. B
21. B	22. C	23. B	24. C	25. D
26. C	27. C	28. C	29. C	30. D

31. 7.1×10^{-19} J.

32. (a) 1.0 eV; (b)(i) 1.0 V; (ii) 0.75 V;
both with collector negative w.r.t. emitter.

33. 2.2 V

34. (a) 1.6×10^{-19} J (1.0 eV); (b) 2.41 V;
(c) −1.56 V.

36. 1.33×10^{-15} J. 37. 5.20×10^{14} Hz.

38. 5×10^{-19} J, 3×10^{-19} J.

39. (a) 4.56×10^{-19} J; (b) 1.50×10^{-19} J.

40. (c)(i) 3.20×10^{-18} J; (ii) 2.56×10^{-18} J.

41. (b)(i) 1.0 V; (ii) 1.6×10^{-19} J (1.0 eV);
(iii) 3.85×10^{-19} J.

42. (a) 1.60×10^{-19} J; (b) 5.23×10^{-19} J;
(c)(i) 3.63×10^{-19} J; (ii) 547 nm.

43. (c) 1.31×10^{13} s^{-1}; (d) 8.29×10^{-19} J;
(e)(i) 1.64 W; (ii) 1.98×10^{18} s^{-1};
(iii) 6.63×10^{-6}.

44. (a) 7.8×10^{-19} J. 45. (c) 3.38×10^{-19} J.

47. (i) 2.44×10^{16}; (ii) 2.79×10^{5} m.

48. 3.2×10^{8} e^{-}/sec; (ii) 4.8×10^{-10} W.

49. (a) 3.2×10^{15} s^{-1}; (b) 3.0×10^{9} s^{-1};
(c)(i) 9.4×10^{-7} electrons/photon.

51. (a) 6.0×10^{7}; (b) 7.4×10^{5} s^{-1}; (c) 1.2×10^{-12} W.

53. (b)(i) 4.32 μA; (ii) 0.75 V.

54. (b)(i) 5.34×10^{14} Hz; (ii) 3.54×10^{-19} J;
(iii) 5.28×10^{19} s^{-1}.

55. (c)(i) 6.4 s.

56. (d)(i) 1.6×10^{-19} J; (ii) 4.5×10^{14} Hzl
(iii) 2.98×10^{-19} J;
(iv) 4.11×10^{-19} J, 2.98×10^{-19} J, 1.13×10^{-19} J.

57. (b)(i)(1) 6.4×10^{14} Hz; (2) 7.68×10^{-19} J;
(ii) 6.62×10^{-34} Js.

Wave-Particle Duality

58. D	59. C	60. D	61. D	62. A
63. E	64. B	65. D	66. C	67. C

68. (a) $\sqrt{2}$; (b) 2.7×10^{-11} m; (c) $3^0\,32'$.

69. (a) 3.96×10^{-19} J; (b) 1.32×10^{-27} kg m s^{-1}.

70. ~ 10^{-18} J. 71. $\dfrac{h}{\sqrt{2m_eE}}$.

73. 4.32×10^{-24} kg m s^{-1}; 67 V. 74. 5×10^{-10} m.

75. (a) ~ 0.3 nm; (b) ~ 2×10^{-24} kg m s^{-1}.

76. (a)(i) 4.42×10^{-19} J; (ii) 1.58×10^{17};
(b)(ii) 1.47×10^{-27} Ns; (c)(i) 0.0233 Ns.

79. 1.00×10^{-10} m. 80. (c)(ii) 1.21×10^{-13} m.

Topic 27 Line Spectra

1. C	2. D	3. D	4. E	5. A
6. E	7. C	8. B	9. C	10. E
11. A	12. B	13. C	14. C	15. A
16. E	17. C	18. B	19. C	20. C
21. A	22. C	23. A	24. C	25. C

26. (a) 1.9×10^{-6} m; (b) 6. 28. 1.89×10^{6} ms^{-1}.

32. 1.83×10^{15} Hz, 9.86×10^{15} Hz, 1.17×10^{15} Hz; UV.

33. (a) 1.39×10^{-18} J;
(b)(i) D; (ii) 2.46×10^{-7} m; (iii) UV.

34. (b) 4.09×10^{-19} J.

35. 4.43×10^{-7} m, 4.95×10^{-7} m, 6.6×10^{-7} m;
$R = 1.08\times10^{7}$ m^{-1}; 3.7×10^{-7} m.

36. (a)(i) 5 to 1; (ii) 10; (b) 4; (c)(i) None;
(ii) 2 to 1; (iii) 2 to 1, 3 to 1, 3 to 2;
Range: 2.11 V to 5.13 V; 3.4×10^{-22} J.

37. (a) UV; (b) 2.18, 2.09, 2.04, 1.94, 1.64 Aj.

38. 9.6×10^{-19} J; 3.6×10^{-4} ms^{-1}.

39. (c)(i) 4.86×10^{-7} m; (ii) 3.65×10^{-7} m.
40. (c)(ii) 634 nm; (iii) B to C; (iv) UV.

41. (a)(ii) 3.01×10^{-19} J; (c)(i) 4.00^0.

Topic 28 Nuclear Physics

1. C	2. E	3. B	4. D	5. C
6. C	7. E	8. C	9. B	10. D
11. D	12. C	13. B	14. A	15. A
16. A	17. C	18. C	19. A	20. A
20. D	22. A	23. C	24. D	25. C
26. C				

27. 1.66×10^{-27} kg. 29. 8.2×10^{-14} J.

31. (a) 1.4×10^{44} m^{-3}; (b) 2.4×10^{17} kg m^{-3}.

32. 1.11×10^{-17} kg. 33. (b) 1.89×10^{-13} J.

34. 12.10 m_u. 35. 3.59×10^{-13} J.

37. (a) 6 electrons, 6 protons, 6 neutrons;
(b) 12.0990 m_u.

38. (a) 2000 kg; (b) 4.4×10^{-7} kg.

41. (c)(ii) $^{205}_{81}\mathrm{Tl}$; (iii)(1) 81; (2) 124.

42. (b)(i) 3.42×10^{31} J.

43. (a)(i) $2\,^{1}_{0}\mathrm{n}$; (ii) fission; (b)(i) 226.5 MeV.

44. (b) 1.992×10^{-30} kg; (c) 1.79×10^{-13} J;
(d) 3.51×10^{6} ms^{-1}, right.

45. 5.1×10^{16} J; 1 month.

46. (a) 2.38×10^{13} photons; (b) 8.9×10^{-23} kg.

47. $(2.990\pm0.003)\times10^{-13}$ J.

48. 2.8×10^{-12} J; 3.1×10^{-29} kg;
2.14×10^{8} W; 1.93×10^{9} W.

49. (d)(i) 8.96×10^{-13} J; (ii) 1.63×10^{7} ms^{-1}.

51. (b) 6.5×10^{-13} J; (c) 1.4×10^{7} ms^{-1}, 2.4×10^{5} ms^{-1}, ii
opposite directions; (d) 7.34×10^{-30} kg.

52. (a)(i) 35; (ii) 46; (b) 1.399×10^{-12} J/nucleon.

53. 4.5×10^{-12} m. 54. (a) 7.2×10^{-45} m^3; (c) 57 N.

55. (b)(iii) 25.20654 u; (iv) 3.3×10^{-11} J.

58. (e)(i) 0.00605 u or 1.004×10^{-29} kg;
(ii) 9.04×10^{-13} J.
59. (c)(i) 34.8 MeV.

60. (c)(i) $^{1}_{0}\mathrm{n}$, 3.

Topic 29 Radioactive Decay

1. D	2. B	3. A	4. A	5. B
6. A	7. B	8. C	9. E	10. C
11. D	12. C	13. C	14. C	15. D
16. D	17. D	18. B	19. E	20. A

21. (a) $^{207}_{81}Tl$, $^{211}_{84}Po$, $^{207}_{82}Pb$; (b) β decay.

22. 6.0 MeV. 23. 6 α-particles, 4 β-particles.

24.

	α	β	γ
charge	+2e	-e	no charge
mass	4u	1/1820 u	0
Typical speed	0.1 c	0.3 - 0.9c	c
nature	particle	Particle	em wave
penetrating ability	stopped by few cm of air	stopped by few mm of Al	stopped by 10 cm of Pb

25. (b)(ii) α; (c)(i) β. 26. (b) 2.1×10^{7} ms^{-1}.

27. 3 months. 28. 1.6×10^{23} He atoms.

29. (c) 0.16 u. 30. (c) 8.53×10^{-4} m; (d) ⊇ 2 m.

Law of Decay

33. D	34. D	35. D	36. A	37. C
38. C	39. D	40. B	41. A	42. D
43. E	44. C	45. C	46. C	47. A
48. D	49. B	50. D	51. D	52. C
53. D	54. C	55. C	56. A	57. A

58. (b) 7×10^{5}. 59. 4.01×10^{4} Bq.

60. 3.8×10^{-12} kg. 61. 3.75×10^{7} Bq.

62. ~ 85 s. 63. (d) 1/32.

64. (b)(i) 3.51×10^{21}; (ii) 3.79×10^{8} s;
(iii) 6.81×10^{12} Bq.

65. (b)(ii) 4.18×10^{-9} s^{-1}; (iii) 4.19×10^{13} Bq.

67. (a)(i) 2.69×10^{4} Bq; (ii) 4.94×10^{14};
(b) 5.44×10^{-11} s^{-1}; (c) 1.27×10^{10} s.

68. (b)(ii) 112 s^{-1} cm^{-2}.

69. (b)(iii)(1) 0.984; (2) 1.6%, decrease.

70. (b)(i) $^{40}_{19}K\rightarrow^{40}_{18}Ar+^{0}_{1}\beta$; (ii) positron;
(c)(i) 4.2×10^{9} yr; (ii) underestimate.

71. $\delta N = (K - \lambda N)\,\delta t$; $N \rightarrow$ constant value when $\frac{\delta N}{\delta t} \rightarrow 0$, i.e. when $K = \lambda N$.

72. $^{221}_{87}Fr$.

73. 4.9×10^{-18} s^{-1}; 1.6×10^{4} kg; 2×10^{11} s^{-1}.

74. One decay per 5 years; 1 : 1.

75. (c) 9.5 counts per min; (d) 10.8 counts per min.

76. 7.2×10^{-15} J; 8.0×10^{-32} kg; 4 s; 2680 AD.

77. 15100 s. 78. 8.10×10^{-6} kg.

79. (a) (1.28±0.05) days; (c) 0.54/day or 6.3×10^{-6} s^{-1}.

80. (c)(i) 30 counts per min; (ii) 27.6 days.

81. (c)(ii) 0.012 s^{-1}, 57 s.

82. (c)(ii) 4.1×10^{9} yr. 83. (b)(ii) 1.1.

85. (c)(i) 0.0154/day; (ii) 3.37×10^{7} Bq;
(iii) 9.94×10^{-5} kg.

86. (b)(i) $^{222}_{86}Rn\rightarrow^{218}_{84}Po+^{4}_{2}He+\gamma$;
(iii)(1) 1.22×10^{-29} kg; (2) 2.26×10^{-12} m.

Topic 31 Option C - The Physics of Materials

1. A	2. B	3. A	4. C	5. D
6. D	7. A	8. B	9. E	10. B
11. B	12. E	13. A	14. C	15. C
16. C				

17. *E*. 18. 2.6×10^{-4} m^{2}.

19. 2.4×10^{7} Pa; 3.0×10^{-5} m.

20. 840 N; 6.3 mJ.

22. (b)(i) 0.68 J; (ii) 2.9 m.

23. (b)(i) 0.0106 m; (ii) 3.81 kJ.

24. (a)(i) Y; (ii) X; (iii) Z;
(c)(i) 0.030 J; (ii) 0.64 J.

25. (a)(i) 64 MPa; (ii) 5.82×10^{-4}; (iii) 1.45 mm.
(b)(i) 1.69×10^{-5} Ω.

26. (a) elastic; (c)(i) 2.33×10^{7} Pa; (ii) 9.17×10^{-3}.

27. (b) 7.5×10^{-6} rad.

29. (b) Up to 1.4 mm; 1.56×10^{11} Pa; (c) 0.33 J.

30. (c) 1.19×10^{11} Pa.

31. (b)(ii) 1.60×10^{11} Pa. 32. 6 mm; 0.06 mm.

33. 7.5 m.

34. (a) MT^2; (c) $K' = 2K$; (d) $\frac{1}{2}K'x_1^2$;
(i) 0.98 J; (ii) 0.49 J.

36. (c)(i) 1.977×10^{11} Pa, 0.2×10^{11} Pa.

37. (b)(ii) 1.1×10^{9} Pa in compression,
2.0×10^{9} Pa in tension;
(c)(i) 13800 N; (li) 9.5 mm; (iii) 66 J.

38. (c)(i) 2.8%; (ii) (92±3) Nm^{-1}; (d) 4.6%.

39. (c)(ii) 5.0 mm.

40. (c)(i) 1.36 kN; (ii) 67.8 mm^2.

41. (b)(i)(1) 6.72 ms^{-1}; (2) 17.5 J;
(ii)(1) 1.33×10^{-3}; (2) 17.5 J; (3) 10900 N;
(4) 21800 N; (5) 1.97×10^{11} Pa.

42. (d)(i) 3.8×10^{-3} kg; (ii) 4×10^{-3};
(iii)(1) 0.192 J; (2) 3.84 J; (v) 2.25 K.

43. (a)(i)(1) $k = \frac{W}{e}$; (2) $E = \frac{W\ell}{Ae}$
(iii) 8.29×10^{4} Nm^{-1};
(b)(iii)(1) 440 rad s^{-1}; (2) 264 ms^{-1}.

Topic 32 Option F – The Physics of Fluids

2. (c) 0.4905 ms^{-2}. 11. (c)(i) 1.96×10^{5} N.

12. (b)(i) 6375 Pa; (ii) 1.15×10^{5} N.

13. (c)(ii) 0.149 m.

14. (a)(i)(1) 73.1 N; (2) 69.1 N.

16. (b)(i) 1.18×10^{8} N; (ii) 1.20×10^{4} m^3.

17. (a)(i) 39.2 N; (ii) 8/15;
(iii) 3.5 cm below centre of gravity;
(c)(ii) 0.158 ms^{-1}; (iii) 1.14 ms^{-2}.

18. (a)(ii)(1) 0.0205 N; (2) 0.707 kg m^{-1} s^{-1}.

19. (b)(ii) 2.08 cms^{-1}; (iii) 0.816 Pa.

20. (b)(i) 8.57×10^{-4} ms^{-1}; (ii) 2.06×10^{-4} Pa.

21. (c)(i) 2.83 ms^{-1}; (iii) streamline.

22. (b) $v_Y = \frac{A_X v_X}{A_Y}$; (c)(i) $\frac{1}{2}m(v_Y^2 - v_X^2)$.

23. (c)(i) 66.6 kW.

25. (a) 1.76ms^{-1}; (c) 1.19 kPa.

Topic 33 Option M – Medical Physics

9. *(b)* 0.031 W
23. *(b)* (iii) 1.59×10^{-4} W
29. *(c)* (ii) 77 dB

Topic 34 Option P – Environmental Physics

2. *(b)* (i) summer – 67.9 %
winter – 70.2 %
(ii) P_{input} = 1765 MW
P_{wasted} = 1165 W
5. *(b)* (ii) 12.7 kWh