1. **B** : Using $s = ut + \frac{1}{2} g t^2$ with $s = 0.078$ m and $t = 0.040$ s gives $u = (s : \frac{1}{2} g t^2)/t \approx 1.8$ m s^{-1}.

2. **A** : Resolving the lift L: $L \cos\theta = mg$; horizontal component $L \sin\theta = m v^2 / r$. Dividing gives $\tan\theta = v^2 / (r g)$, so $v = \sqrt{(r g \tan\theta)}$.

3. **C:** Using $v_x = v \cos\theta$ and $v_y = v \sin\theta$:
   $t = 36 / (22 \cos 40°) \approx 3.04$ s.
   $y = 1.2 + v_y t - \frac{1}{2} g t^2$
   $= 1.2 + 22 \sin 40° \times 3.04 - 0.5 \times 9.81 \times 3.04^2 \approx 9.0$ m.

4. **C**: Momentum conservation (rightwards +):
   $m_□ u = m_□(-v) + m_□ V$
   $\Rightarrow V = m_□(u + v) / m_□$
   $= 0.20 (0.50 + 0.30) / 0.80 = 0.20$ m s^{-1}.

5. **C**: $W = mgh = 2.0$ kg $\times 9.8$ m $s^{-2} \times 3.0$ m $\approx 5.9 \times 10^1$ J.

6. **B**: Work $= mgh = 4.9 \times 10^2$ J; power $= W / t = 4.9 \times 10^2$ J $/ 4.0$ s $\approx 1.2 \times 10^2$ W.

7. **C**: Using the parallel-axis theorem, $I_A = I_{cm} + m d^2$ (with *d* the half-width), so I_A is greater than I_B ($= I_{cm}$).

8. **C**. Energy: $mgh = \frac{1}{2} I \omega^2 + \frac{1}{2} m (\omega R)^2$ with $I = \frac{1}{2} MR^2$; solving gives $\omega \approx 9.9$ rad s^{-1}.

9. **C**: Clockwise torque = anticlockwise torque about the wire:
   $1.1\, m a = m x \Rightarrow x = 1.1\, a = 0.22$ m.

10. **C**. $\gamma = 1 / \sqrt{(1 - \beta^2)} = 5.0$; lifetime in Earth frame $\tau = \gamma \tau_0 = 11$ μs; distance $v \tau = 0.98 c \times 11$ μs ≈ 3.3 km.

11. **A** : Energy supplied $Q = P t = (120\text{ W})(300\text{ s}) = 3.6 \times 10^4$ J. Mass evaporated $m = 0.034$ kg. $L = Q/m \approx 1.1 \times 10^6$ J kg^{-1}.

12. **A** : For an isothermal change, $p_1V_1 = p_2V_2$. Hence $p_2 = p_1 (V_1 / V_2) = (8.0 \times 10^5 \text{ Pa})/4 = 2.0 \times 10^5$ Pa.

13. **D**: For adiabatic change $TV^{(\gamma-1)}$ = constant; $T_2 = T_1 (V_1 / V_2)^{(\gamma-1)} = 300 \text{ K} \times 2^{0.4} \approx 4.0 \times 10^2$ K.

14. A. Carnot efficiency $\eta = 1 - T_c / T_h = 1 - 300 / 600 = 0.50$.

15. **B:** Each lamp has resistance $R = V^2/P = 12^2 / 40 = 3.6\ \Omega$.
    Two lamps in parallel give $R_{eq} = 1.8\ \Omega$. Total resistance $= 1.8 + 0.5 = 2.3\ \Omega \rightarrow I = 12 / 2.3 \approx 5.2$ A.
    Voltage across lamps $V_{lamp} = I R_{eq} \approx 9.4$ V.
    Power per lamp $= V_{lamp}^2 / R \approx 9.4^2 / 3.6 \approx 25$ W.

16. **B**: $I = \varepsilon / (R + r) = 12\ V / 6.0\ \Omega = 2.0\ A$; $P = I^2R = 4 \times 5.6\ W = 22\ W$.

17. **C** : $T = 2\pi\sqrt{(l/g)} = 2\pi\sqrt{(0.90\ m/9.8\ m\ s^{-2})} \approx 1.3\ s$.

18. **D:** Electromagnetic waves are transverse and can exhibit polarisation; sound waves in air are longitudinal, so their oscillations are parallel to the direction of propagation and cannot be polarised.

19. **B**: $\theta \approx \lambda / d = 6.0 \times 10^{-7}\ m / 3.0 \times 10^{-4}\ m = 2.0 \times 10^{-3}$ rad.

20. **B** : $\lambda = s\,d/D = (3.2 \times 10^{-3}\ m)(2.5 \times 10^{-4}\ m)/4.0\ m \approx 6.3 \times 10^{-7}\ m$.

21. **B:** For the first order, $d \sin\theta = \lambda$. From the geometry $\tan\theta = x/D$ and for small angles $\sin\theta \approx \tan\theta$, so $\lambda \approx d\,(x/D)$. Because d (= grating spacing) cancels in every option except B, only B gives the correct proportionality.

22. **D:** For a string fixed at both ends, harmonics have frequencies $f_n = n f_1$. The second overtone is the third harmonic ($n = 3$): $f_3 = 3 \times 196$ Hz = 588 Hz.

23. **C**: $f' = f\,v / (v - v_s) = 700\ Hz \times 340 / 310 \approx 7.7 \times 10^2$ Hz.

24. **B:** For a moving source approaching a stationary observer:
$f = f_s \cdot v_{sound} / (v_{sound} - v)$
$894 = 800 \cdot 340 / (340 - v) \rightarrow 340 - v = 800 \times 340 / 894 \approx 304 \rightarrow v \approx 36\ m\ s^{-1}$.

25. **C**: $v_e = \sqrt{(2GM/R)} = \sqrt{[2 \times 6.67 \times 10^{-11} \times 4.0 \times 10^{23} / 1.6 \times 10^6]} \approx 5.8 \times 10^3\ m\ s^{-1} = 5.8\ km\ s^{-1}$.

26. **C** : $E = V/d = 430\ V/0.067\ m \approx 6.4 \times 10^2\ V\ m^{-1}$.

27. **B:** For equilibrium: $qE = mg$, with $E = V / d = 450\ V / 0.005\ m = 9.0 \times 10^4\ V\ m^{-1}$.
$q = mg / E = (1.6 \times 10^{-15}\ kg)(9.81\ m\ s^{-2}) / 9.0 \times 10^4 \approx 1.7 \times 10^{-19}$ C, close to one elementary charge.

28. **B**: $r = 0.06$ m; $v = qBr/m = (1.6 \times 10^{-19}\ C)(0.20\ T)(0.06\ m)/(3.3 \times 10^{-26}\ kg) \approx 5.8 \times 10^4\ m\ s^{-1}$. $KE = \frac{1}{2}mv^2 \approx 5.6 \times 10^{-17}\ J = 3.5 \times 10^2$ eV.

29. **D**: $\varepsilon = N\,\Delta\Phi / \Delta t = 200 \times 0.015\ m^2 \times 0.20\ T / 0.40\ s = 1.5\ V$.

30. **C**: $P_{in} = 120\ V \times 4.0\ A = 480\ W$; $P_{out} = 0.95 \times 480\ W = 456\ W$; $I_s = P_{out} / V_s = 456\ W / 3000\ V \approx 0.15\ A$.

31. **C**: $\lambda_{max} = b/T \approx 10\ \mu m$; CO_2 absorption bands lie in the 4 - 20 μm thermal infrared where Earth emits most strongly, trapping heat.

32. **C**: $R = 1.2\ fm \times (197)^{(1/3)} \approx 7.0$ fm.

33. **A**: Photon energy $E = 1240\ eV\ nm / 350\ nm \approx 3.5\ eV$; $K_{max} = E - \varphi = 3.5\ eV - 2.3\ eV \approx 1.2\ eV$.

34. **B**: $\lambda = h / \sqrt{2 m e V} \approx 0.10$ nm.

35. **C**: $(1/2)^{(t/T_{1/2})} = 0.625 \rightarrow t/T_{1/2} = \ln 0.625 / \ln 0.5 \approx 0.677 \rightarrow T_{1/2} = 10 / 0.677 \approx 15$ days.

36. **B**: Energy per fission = 200 MeV = 3.2×10^{-11} J; $n = P / E = 1.5 \times 10^{9}$ W / 3.2×10^{-11} J $\approx$ 4.7×10^{19} s^{-1}.

37. **A**: Energy is released when the product nucleus has a higher binding-energy-per-nucleon (lower total mass) than the reactants.

38. **C:** $\Delta E = \frac{1}{2} I (\omega_a^2 - \omega_\beta^2)$
$= \frac{1}{2} \times 150 (160^2 - 120^2) \approx 8.4 \times 10^5$ J.
$P = \Delta E / t = 8.4 \times 10^5$ J / 8.0 s $\approx 1.05 \times 10^5$ W.

39. **B:** Horizontal radius: $r = 3.9$ m + 11.1 sin 35° $\approx$ 10.3 m.
For a conical pendulum, $\tan\theta = v^2 / (r g) \Rightarrow \omega = \sqrt{g \tan\theta / r}$.
$\omega = \sqrt{9.81 \tan 35° / 10.3} \approx 0.82$ rad s^{-1}.

40. **C**: ^{235}U readily undergoes fission upon capturing a low-energy (thermal) neutron.