2015 H2 Physics Prelim Paper 1 Solutions

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

1 **D** Using first principle:

Largest difference: D_{max} = 12.9 – 11.3 = 1.6 m
Smallest difference: D_{min} = 12.5 – 12.1 = 0.4 m
Average difference: D_{ave} = (D_{max} + D_{max})/2 = (1.6 + 0.4)/2 = 1.0 m
Uncertainty in difference: ΔD = (D_{max} – D_{max})/2 = (1.6 – 0.4)/2 = 0.6 m

Using formula:
H_1 = 12.7 ± 0.2 m
H_2 = 11.7 ± 0.4 m
$D = H_1 - H_2$ = 12.7 – 11.7 = 1.0 m
$\Delta D = \Delta H_1 + \Delta H_2$ = 0.2 + 0.4 = 0.6 m

2 **D** $\Delta v = v - u = v + (-u)$

3 **B** Velocity on the way up and down must be of different sign conventions (C & D are wrong). Velocity at the top is zero. Constant gradient on the way up and down since acceleration is constant. On hitting ground, direction of velocity suddenly changes (A is wrong) and its magnitude is lower due to energy loss.

4 **A** $y = \frac{1}{2}at^2$ (u = 0 since released from rest)

$2y = \frac{1}{2}at'^{\,2}$

$t' = \sqrt{2}\,t = 1.41t$

$t' - t = 0.41t$

5 **B** For object B to remain at rest, the force exerted by object C on object B must be equal to the sum of the weight of B and the force exerted by object A on object B.

6 **B** Applying principle of conservation of momentum,
$m \times 150 = (m \times v_1) + (9m \times v_2)$
$150 = v_1 + 9 \times v_2$ - - - (1)

Applying relative of approach = relative of separation (or conservation of KE),
$150 - 0 = v_2 - v_1$
$v_2 = 150 + v_1$ - - - (2)

Substituting (2) into (1),
$150 = v_1 + 9 \times (150 + v_1)$
$-1200 = 10\, v_1$
$v_1 = -120 \text{ m s}^{-1}$

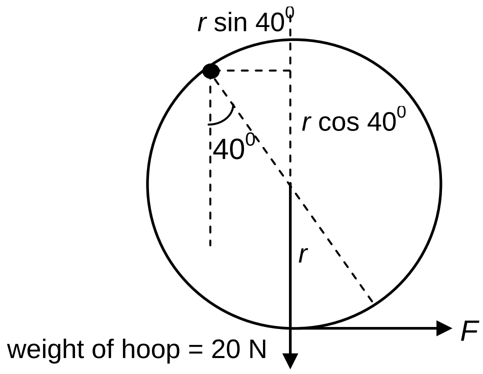
7 **A** Let r be the radius of the hoop.

Taking moments about the pin,

$$20\left(r \sin 40^o\right) = F\left(r + r\cos 40^o\right)$$

$$F = \frac{20\left(r \sin 40^0\right)}{\left(r + r\cos 40^0\right)}$$

$$= 7.28 \text{ N}$$



8 **D**

- The horizontal components of the reaction forces R_1 and R_2 should be equal but opposite, otherwise there will be a net horizontal force.
- The CG of the structure is at the mid-point of the line joining the centres of the two uniform rods. Since the CG is nearer to the left rod, the vertical component of R_1 should be bigger than that of R_2 such that the sum of the vertical components of R_1 and R_2 is equal to $2W$.
- When in equilibrium, the lines of actions of R_1 and R_2 should intersect at the vertical line passing through the CG of the structure.

A is wrong because R_1 and R_2 are equal in magnitude.
B is wrong because R_1 has a smaller magnitude than R_2.
C is wrong because friction exists on the rough floor.

9 **D** Applying the principle of conservation of energy,
$\Rightarrow$ loss in GPE = gain in EPE

$$\Rightarrow mgh = \frac{1}{2}ke^2$$

$$\Rightarrow k = \frac{2mgh}{e^2} = \frac{2(80.0)(9.81)(45.0)}{(15.0)^2} = 314 \text{ N m}^{-1}$$

10 **C** Rolling down slope:
$mg \sin\theta = F_{\text{resistive}}$

Moving up slope:
$F_{\text{driving}} = mg \sin\theta + F_{\text{resistive}} = 2\, mg \sin\theta = 2 \times 4.0 \times 10^3 \times 9.81 \times \sin 5.0^o = 6840 \text{ N}$
Power $= F_{\text{driving}}\, v = 6840 \times 6.0 = 41040 = 41 \text{ kW}$

11 **C** Applying Newton's 2nd law of motion at the bottom of the circular motion,

$$F_{net} = ma_c$$

$$T - mg = \frac{mv^2}{L}$$

$$T = \frac{mv^2}{L} + mg \quad \text{..... (1)}$$

Applying the principle of conservation of energy,
KE gained = GPE lost

$$\frac{1}{2}mv^2 - 0 = mg(L\sin 30^o + L)$$

$$\frac{mv^2}{L} = 2mg(1.5) \quad \text{..... (2)}$$

Substitute (2) in (1): $T = 3mg + mg = 4mg$

12 **B** $F_c = f = km$, where k is the constant of proportionality

$$\frac{mr\omega^2}{(\tfrac{1}{4}m)r'\omega^2} = \frac{km}{k(\tfrac{1}{4}m)}$$

$r' = r$, since both cubes experience the same angular velocity ω

13 **B** Net force $= \frac{GMM}{(2R)^2} + \frac{GMM}{(\sqrt{2}R)^2}\cos 45° + \frac{GMM}{(\sqrt{2}R)^2}\cos 45° = \frac{0.25GM^2}{R^2} + \frac{\sqrt{2}GM^2}{2R^2} = \frac{0.96GM^2}{R^2}$

14 **A**

$$F_c = F_g$$

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$v = \sqrt{\frac{GM}{r}}$$

$\therefore$ If r decreases, v increases.

15 **B** Distance travelled from t = 0 s to t = 1.0 s is 0.020 m.
But distance travelled from t = 1.0 s to t = 1.5 s is not 0.010 m.

Displacement from origin at t = 1.5 s is
$x = x_o \sin(\omega t) = 0.020\sin(2\pi \times 0.25 \times 1.5) = 0.014\,\text{m}$.

Distance travelled from t = 1.0 s to t = 1.5 s is 0.020 – 0.014 = 0.006 m.

Total distance = 0.020 + 0.006 = 0.026 m, not 0.030 m.

16 **C** Since the graph shows that U increases as the body moves away from the equilibrium position, by applying $F = -\text{d}U/\text{d}x$ to the graph, it is shown that force F acts in the opposite direction to displacement x, ie force is directed towards O.

17 **B** Mean kinetic energy of neutron $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$

$$\frac{1}{2}\left(1.67\times10^{-27}\right)\langle c^2\rangle = \frac{3}{2}\left(1.38\times10^{-23}\right)\left(273.15+35\right)$$

$$\sqrt{\langle c^2\rangle} = 2764\ \text{m s}^{-1}$$

18 **D** Internal energy of a body is the sum of its microscopic kinetic and potential energies. Potential energy of the atoms increases as their separation increases due to stretching.

19 **C** ¾ λ = 5 cm (based on measurements taken from the figure)
λ = 6.67 cm = 1.33 m (since metre rule is 5 cm on the figure)

T = 1/10 s (since 10 frames were taken in 1 s)

$v = \lambda/T$ = 13.3 m s^{-1}

20 **D** As the wave is moving to the left, particle Q must move downwards the next instant.

$\lambda \approx$ 6.45 cm and Q is ahead of P by $\approx$ 1.05 cm.

Therefore, phase difference or angle between P & Q = $\frac{1.05}{6.45}\times 360^\circ \approx 60^\circ$.

21 **B** Since the lines represent crests, troughs are mid-way between any two consecutive lines. Therefore, Z is a constructive inference of two troughs (B & C) and Y is a destructive interference of a crest and a trough (A & B). As a check, X is a constructive interference of two crests (B & D).

22 **A** Distance between 2 consecutive nodes = $\lambda/2$ = 0.40 m
$\Rightarrow \lambda$ = 0.80 m
$\therefore f = v/\lambda$ = 300/0.8 = 375 Hz

Fundamental frequency is produced when $L = \lambda_o/2$ = 1.20 m
$\Rightarrow \lambda_o$ = 2.40 m
$\therefore f_o = v/\lambda_o$ = 300/2.40 = 125 Hz

23 **C** $F = \frac{2Q^2}{4\pi\varepsilon_0 r^2} - \frac{3Q^2}{4\pi\varepsilon_0 (2r)^2} = \frac{5Q^2}{16\pi\varepsilon_0 r^2}$

24 **D** The potential within a conducting sphere (hollow or solid) is constant of no current is flowing through it. (From $E = -\mathrm{d}V/\mathrm{d}r$, this means that the electric field within is zero.)

25 **D** Each strand in the cable has resistance nR.
Thus, the original wire has resistance $n(nR) = n^2R$.

26 **A** $E - ir = V_{terminal}$

During discharging: $E - 3.0r = 8.5$ (1)

During charging: $E + 2.0r = 11$ (2)

$(2)-(1)$: $5.0r = 2.5 \Rightarrow r = 0.5\ \Omega$

27 **A** When switch S is closed, $V_1 = \dfrac{E}{2}$

$$P_1 = \frac{V_1}{R_1} = \frac{(\frac{E}{2})^2}{R} = \frac{E^2}{4R} = P_4$$

When switch S is opened, $R_{13} = \dfrac{R}{2}$, $V_1' = \dfrac{E}{3}$, $V_2' = \dfrac{2E}{3}$

$$P_1' = \frac{(\frac{E}{3})^2}{R} = \frac{E^2}{9R} < P_1$$

$$P_4' = \frac{(\frac{2E}{3})^2}{R} = \frac{4E^2}{9R} > P_4$$

28 **A** Increasing the resistance of R will decrease the potential difference across the wire XY and hence increase the balance length.

29 **D** $B_P = \dfrac{\mu_0(3.0)}{2(0.10)} = 15\mu_0$

$B_Q = \dfrac{\mu_0(5.0)}{2(0.20)} = 12.5\mu_0$

Since $B_P > B_Q$, current in P is anti-clockwise while current in Q is clockwise to produce B_{net} pointing out of the page.

30 **C** $T = N(BIL\cos 30°)L$

$= 40 \times 0.010 \times 0.0080 \times 0.012 \times \cos 30 \times 0.012$

$= 4.0 \times 10^{-7}$ N m

31 **A** Both halves of the rod have induced emf of the same magnitude, but opposite in directions. Hence, they cancel each other when measured across both ends.

32 **C** average e.m.f $= -\dfrac{\Delta\Phi}{\Delta t} - \dfrac{NBA\cos 150° - NBA\cos 30°}{t}$

$$= -\frac{(10)(0.15)(1.2)(\cos 150° - \cos 30°)}{2.0}$$

$$= 1.6\ \text{V}$$

33 **C**

Average power dissipated in the resistor before diode is added $= \frac{120^2}{R}$

For full-wave: $V_{rms} = \frac{V_o}{\sqrt{2}}$

For half-wave: $V_{rms}' = \frac{V_o}{2} = \frac{\sqrt{2}V_{rms}''}{2}$

For same power output:

$$\frac{(V_{rms}')^2}{R} = \frac{120^2}{R}$$

$$\left(\frac{\sqrt{2}V_{rms}''}{2}\right)^2 = 120^2$$

$$V_{rms}'' = 120\frac{2}{\sqrt{2}} = 120\sqrt{2}\text{ V}$$

34 **A**

Pd across secondary coil $= 120 \times \frac{1}{60} = 2.0$ V

Current in secondary coil $= \frac{V}{R} = \frac{2.0}{3.0}$ A

Current in primary coil $= \frac{2.0}{3.0} \div 60 = 0.011$ A

35 **C**

$$k_\alpha \text{ peak } = 0.154 \text{ nm}$$

$$\lambda_{\min} = \frac{0.154 \times 10^{-9}}{3} \text{ m}$$

maximum KE of electrons = energy of X-rays of wavelength $\lambda_{\min}$

$$\frac{1}{2}mv^2 = \frac{hc}{\lambda_{\min}}$$

$$v = \sqrt{\frac{2hc}{m\lambda_{\min}}} = \sqrt{\frac{2(6.63\times10^{-34})(3.00\times10^{8})(3)}{(9.11\times10^{-31})(0.154\times10^{-9})}}$$

$$= 9.22\times10^{7} \text{ m}$$

36 **A** Uncertainty in the position of the photon:

$\Delta x = c \times t = (3.00 \times 10^8)(3.0 \times 10^{-9}) = 0.90$ m

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

$$\Delta p = \frac{h}{4\pi\Delta x}$$

$$= \frac{6.63\times10^{-34}}{4\pi(0.90)}$$

$$= 5.9\times10^{-35} \text{ kg m s}^{-1}$$

37 **D** A: Collimated beam just means a parallel beam.

B: Coherence means constant phase difference, not constant phase. Also, laser is produced by stimulated emission, not spontaneous.

C: Same-frequency photons and spontaneous de-excitations from meta-stable state do not guarantee coherence

38 **B** Electrons in the valence band (VB) absorb the energy of the incident photons to jump cross the band-gap into the conduction band (CB). Resistivity is reduced due to the presence of electrons in the CB and holes in the VB.

39 **C** Energy released = binding energy of product – binding energy of reactant
= 2.54 x 3 – 2 x 2 x 1.09
= 3.26 MeV

40 **B**

time / days	true count rate / s^{-1}
7	122
14	100
21	84

Applying $A = A_0 e^{-\lambda t}$,

$$\Rightarrow 84 = 122e^{-\frac{\ln 2}{t_{1/2}}(14)}$$
$$\Rightarrow \frac{\ln 2}{t_{1/2}}(14) = \ln\left(\frac{122}{84}\right)$$
$$\Rightarrow t_{1/2} = 26 \text{ days}$$