2024 DHS H1 Physics Prelim Paper 1 Suggested Solutions

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

Worked Solutions & Explanations:

1 **D**

Units of v = m s^{-1}

Units of $\sqrt{g\lambda}$ = $\sqrt{\text{m s}^{-2} \times \text{m}}$ = $\sqrt{\text{m}^2 \text{ s}^{-2}}$ = m s^{-1}

2 **A**

For a pair of forces of magnitude X and Y,

$$\text{Minimum } F_{net} = |X - Y| = 6 - 4 = 2 \text{ N}$$

$$\text{Maximum } F_{net} = |X + Y| = 6 + 4 = 10 \text{ N}$$

Hence, the resultant force cannot be 1 N.

3 **A**

average length measured = 891.5 mm

difference from true value = 895 mm – 891.5 mm = 3.5 mm

(results are not accurate to within 1 mm)

$\Delta L = L_{max} - L_{avg}$ = 0.5 mm **(results are precise to within 1mm)**

4 **B**

$v_y^2 = u_y^2 + 2as$

At max height, vertical component of velocity = 0

$$v_y^2 = 0 + 2(9.81)(13.0) = 255.06 \text{ m s}^{-1}$$

horizontal component of velocity is a constant, v_x = 22 cos 30°

$v = \sqrt{v_y^2 + v_x^2} = \sqrt{225.06 + 22^2 \cos^2 30°} = 24.9 \text{ m s}^{-1}$

5 **D**

The total area under the acceleration-time graph is the change in velocity. The maximum magnitude of area occurs at point K. Hence magnitude of the change in velocity (and hence speed) is the largest at point K.

The total area under the graph from t = 0 s onwards is also strictly negative. This indicates that the velocity of the object is strictly negative. (car is always moving in the opposite direction to the defined positive from t = 0 to point M). Hence, the maximum displacement is at M.

6 **C**

The 6.0 kg mass will accelerate upwards (F_{net} upwards), while the 10 kg mass will accelerate downwards (F_{net} downwards)

By considering the free body diagrams of the two masses,

From the 6.0 kg mass:	$T - 6g = 6a$	-------------*(1)*
From the 10 kg mass:	$10g - T = 10a$	------------------*(2)*
(1) + (2):	$4g = 16a$	
	$a = 0.25\,g$	

Therefore, $T = 6g + 6(0.25g) = 7.5g = 74$ N

7 **A**

By Newton's Second Law, the rate of change in momentum is directly proportional to the resultant force. Hence, the resultant force can be determined from the gradient of a momentum-time graph of a body.

At terminal velocity, the momentum of the object is a constant (due to constant v) and non-zero. (graph should be a horizontal line with a non-zero value)

After the time of impact P, the deceleration is a constant and hence net force is a constant. The momentum-time graph should therefore have a constant negative gradient (linear graph sloping downwards) after P.

8 **C**

During a collision, momentum is always conserved. However kinetic energy is only conserved when the collision is elastic.

9 **A**

For an object to be in equilibrium, the three forces must be concurrent (i.e. the line of actions of the 3 forces must intersect at a point). Only option A fits this description.

10 **A**

$F = kx$

$F = (500)\,[(90-60) \times 10^{-3}] = 15\text{ N}$

11 **B**

For a pair of equal and opposite forces,

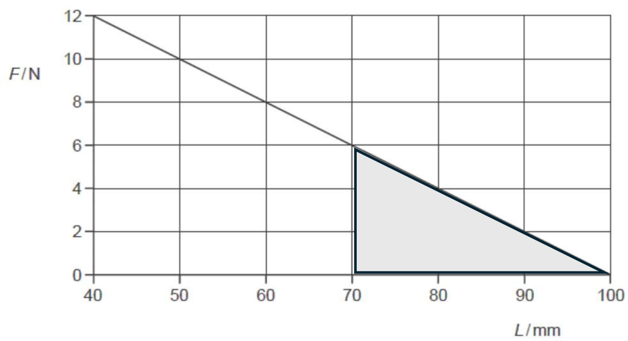
$$\text{torque} = F \times \text{perpendicular distance between the two forces} = F\,(L \sin\theta)$$

12 **C**

Power input = rate of loss of GPE = $\frac{m}{t} gh = (6.0 \times 1000)(9.81)(80) = 4.7088\text{ MW}$

Power output = $0.6 \times 4.7088\text{ MW} = 2.8\text{ MW}$

13 **A**



EPE = area of shaded triangle = $\frac{1}{2} \times 6 \times (30 \times 10^{-3}) = 0.09$ J

14 **C**

At 10 m s^{-1}, $F - 5.0 \times 10^4 = ma$

Driving force, $F = 5.0 \times 10^4 + (3.0 \times 10^5)(0.50) = 2.0 \times 10^5$ N

Power delivered by locomotive = $Fv = 2.0 \times 10^5 (10) = 2.0 \times 10^6$ W

Hence, max speed = $\frac{P}{F_{\text{resistive}}} = \frac{2.0\times10^6}{5.0\times10^4} = 40$ m s^{-1}

15 **D**

For the ball undergoing vertical circular motion, the kinetic energy of the ball is the greatest at the bottom of the loop and decreases as it moves towards the highest point as kinetic energy is converted into gravitational potential energy. Hence the speed of the ball is the greatest at the bottom of the loop.

Since $v = r\omega$, the ball will have the greatest angular velocity at the bottom of the loop.

16 **A**

Triangle OPQ is an equilateral triangle. Hence,

$$\text{angular displacement} = \angle POQ = 60° = \frac{\pi}{3} \text{ rad}$$

17 **B**

For two identical objects lying on the same surface, the **maximum** frictional force is the same.

For the objects to undergo uniform circular motion, the frictional force *F* must provide the centripetal force. Hence,

$$F = mr\omega^2$$

Therefore, for the same angular velocity experienced by P and Q (due to them being on the same rotating disc), the frictional force experienced by the object is directly proportional to its distance from the centre of the disc.

As ω increases, *F* will increase until it reaches a maximum value. When ω is increased even further than the maximum frictional force value, the object will start to slip.

Since $F \propto r$ and $r_P < r_Q$, object Q will reach and exceed the maximum frictional force value before object P, and hence will start to slide first

18 **B**

Effective resistance in circuit = $1000 + \left(\frac{1}{1000} + \frac{1}{1000}\right)^{-1} = 1500\ \Omega$

Current through X = $\frac{1}{2}\left(\frac{V}{R_{eff}}\right) = \frac{1}{2}\left(\frac{1.2}{1500}\right) = 0.0004$ A

Number of electrons passing through per minute = $\frac{It}{e} = \frac{0.0004 \times 60}{1.6 \times 10^{-19}} = 1.5 \times 10^{17}$

19 **D**

The resistance of a NTC thermistor decreases non-linearly with respect to temperature. (Options A and B are incorrect)

The resistance of a NTC thermistor is a finite value at 0°C, hence Option C is also incorrect.

20 **C**

For the same potential difference and current to be tripled when connected in parallel with a 500 Ω resistor,

$$R_{eff,\ parallel} = \frac{1}{3}R$$

$$\left(\frac{1}{500} + \frac{1}{R}\right)^{-1} = \frac{1}{3}R$$

$$\frac{500R}{500 + R} = \frac{1}{3}R$$

$$500 = \frac{1}{3}(500 + R)$$

$$R = 1500 - 500 = 1000\ \Omega$$

21 **B**

Potential difference across 200 kΩ = $\frac{200000}{200000+1000000} \times [3 - (-15)] = 3.0$ V

Hence, potential at X = 3.0 – 3.0 = 0 V

22 **D**

Maximum reading on voltmeter occurs when rheostat resistance is zero. Hence, maximum potential difference across the 15 kΩ resistor is 6.0 V

Minimum reading on voltmeter occurs when rheostat resistance is a maximum at 75 kΩ.

By the potential divider principle,

$$V_{\text{min}} = \frac{15}{15+75} \times 6.0 = 1.0\ \text{V}$$

23 **D**

The magnitude of the magnetic force is given by the product of the magnetic flux density and the component of the length of a current carrying wire **perpendicular** to the magnetic field lines.

$$F = B_{\perp}Il = BIl\ cos\ 60 = BIl \sin 30$$

24 **A**

Since the reading on the top-pan balance increases, the wire exerts a downward magnetic force on the top-pan balance. By Newton's third law, the wire experiences an equal and opposite magnetic force. Hence the **force on the wire XY is upwards**. By Fleming's left-hand rule, pole P is a north pole.

By considering the forces on the magnet,

$$\Delta mg = BIL$$

$$(2.3 \times 10^{-3})(9.81) = B(2.6)(4.4 \times 10^{-2})$$

$$\therefore B = 0.20 \text{ T}$$

25 **D**

Adjacent loops of a spring can be taken to be a pair of current carrying wires. When switch S is closed, the current in adjacent loops will carry current in the same direction with respect to each other.

Hence, regardless of the direction of current of the input signal, the force between loops carrying the same direction of current will be strictly attractive, resulting in a compression in the spring.

26 **C**

Since the mass of P is greater than mass of Q for the same number of nucleons, this implies that the mass defect of Q is greater than the mass defect of P.

With a greater mass defect, the binding energy of Q is greater than P. Hence, nuclei Q is more stable compared to P and would require more energy to be separated into its individual nucleons.

27 **D**

Nuclear fission results in a release of energy. (Hence, options A and B are eliminated)

$$\begin{aligned} E_{released} &= BE_{products} - BE_{\text{reactants}} \\ &= 2(8.45)(118) - 7.65(236) \\ &= 1750 \text{ MeV} \end{aligned}$$

Hence, the energy released per reaction is approximately 1800 MeV

28 **A**

The diagram shows that most of the alpha particles passed through the gold foil undeflected or deflected by small angles.

This indicates that the size of the nucleus relative to the size of the atom is small, as most alpha particles interacting with the gold atoms were not close enough to the nucleus to experience significant electrical repulson and hence, were only deflected by small angles or remain undeflected.

29 **C**

Alpha particles are positively charged and will migrate towards the negative plate Q

Beta particles are negatively charged and will migrate towards the positive plate P

Gamma photons are not electrically charged and will pass through an electric field undeflected

30 **B**

Random nature of a radioactive decay refers to it being impossible to predict which nuclei will decay next. We can only determine the probability of decay through statistical analysis methods (such as taking average).

Hence, for a fixed time interval and fixed number of undecayed nuclei, the number of nuclei that decay fluctuates as the nature of decay is probabilistic rather than deterministic.