VICTORIA JUNIOR COLLEGE
SUGGESTED SOLUTIONS TO 2023 PHYSICS H1 PRELIM EXAM PAPER 1

Q1	**C**	Q7	**A**	Q13	**C**	Q19	**D**	Q25	**B**
Q2	**C**	Q8	**D**	Q14	**D**	Q20	**B**	Q26	**A**
Q3	**B**	Q9	**C**	Q15	**B**	Q21	**B**	Q27	**A**
Q4	**A**	Q10	**C**	Q16	**A**	Q22	**C**	Q28	**B**
Q5	**D**	Q11	**D**	Q17	**C**	Q23	**D**	Q29	**C**
Q6	**D**	Q12	**B**	Q18	**B**	Q24	**C**	Q30	**D**

Q1
Check for homogeneity of equations. An inhomogeneous equation is an incorrect equation.

Let base units be represented by BU.

A: LHS: BU = kg m^2 s^{-2}
RHS: BU = (kg m $s^{-1)}$(m s^{-1}) = kg m^2 s^{-2}
LHS = RHS $\Rightarrow$ homogeneous equation (wrong answer)

B: LHS : BU = (kg m^2 $s^{-2})^2$ = kg^2 m^4 s^{-4}
RHS: BU of p^2c^2 = (kg m $s^{-1)2}$ (m $s^{-1})^2$ = kg^2 m^4 s^{-4}
BU of m^2c^4 = kg^2 (m $s^{-1})^4$ = kg^2 m^4 s^{-4}
All terms on both sides of the equal sign have the same units $\Rightarrow$ equation is homogeneous (wrong answer)

C: LHS: BU = kg m^2 s^{-2}
RHS: BU =(kg m $s^{-1)\,2}$(m s^{-1}) = kg m^3 s^{-3} $\Rightarrow$ inhomogeneous equation (correct answer)

D: LHS: BU = kg m^2 s^{-2}

RHS: BU = $\dfrac{\left(\text{kg m s}^{-1}\right)^2}{\text{kg}} = \text{kg m}^2\ \text{s}^{-2}$ $\Rightarrow$homogeneous equation (wrong answer)

Ans: C

Q2

$$B = \frac{AD}{6C^2} \Rightarrow \frac{\Delta B}{B} = \frac{\Delta A}{A} + \frac{\Delta D}{D} + 2\frac{\Delta C}{C}$$

$$\frac{\Delta B}{B} = \frac{0.1}{2.0} + \frac{0.01}{3.45} + 2\frac{0.05}{4.10} = 7.7x10^{-2} = 7.7\%$$

Ans: C

Q3
The second student's measurements are closer to one another and are therefore more precise compared to the measurements of the first student.

Ans: B

Q4
Area under *v-t* graph is the displacement.

For graph P, the area is always positive, meaning that there is positive displacement.
For graph Q, the area during the negative velocities and the area during positive velocities are equal. Hence the total displacement is zero.
Displacements for graphs P and Q are thus different.

The magnitudes of the total area under the graphs P and Q are *different*. Thus the total distances travelled for P and Q is *different*.

Ans: A

Q5
$v_y^2 = u_y^2 + 2a_y s_y$ for vertical motion

$= 3^2 + 2(-9.81)(-2.4)$ taking upward as positive direction

$v_y^2 = 56.09 \text{ m}^2 \text{ s}^{-2}$

Horizontal velocity, $v_x = u_x = 5.0 \text{ m s}^{-1}$

Speed of toy pilot, $v = \sqrt{\left(v_y^2 + v_x^2\right)} = \sqrt{56.09 + 5.0^2} = 9.0 \text{ m s}^{-1}$

Ans: D

Q6
Here the vertical forces are gravitational and magnetic forces. The horizontal forces are the electric force and air resistance.

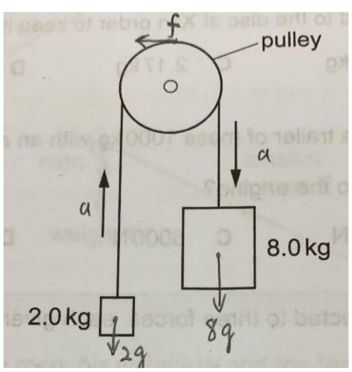
The electrically charged oil drop is moving horizontally at constant velocity. The oil drop is in dynamic equilibrium and the resultant force is zero in all directions.

Vertically, the gravitational force is acting downwards. Therefore, the magnetic force must be acting upwards to ensure equilibrium.

The electric force cannot act vertically in this case because the electric field is horizontal, and air resistance should be acting in the direction opposite to the motion, which is horizontal in this case.

Ans: D

Q7



By N2L and taking the loads-pulley system as a whole,

$8.0g - 2.0g - f = (8.0 + 2.0)a$

$6.0 \times 9.81 - 3.0 = 10.0a$

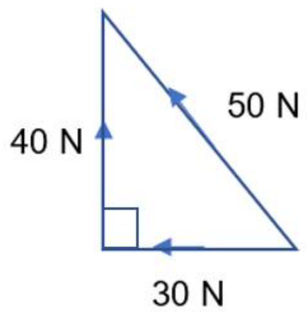
$\therefore a = 5.6 \text{ m s}^{-2}$

Ans: A

Q8
From Newton's 3rd Law, force of P on Q (action force) is equal and opposite to force Q on P (reaction force).

Ans: D

Q9



Ans: C

Q10
Net moment about P = 0 (rotational equilibrium)
$T_1 \times x = T_2 \times (1 - x)$
k_1 (e) $x = k_2$ (e) $(1 - x)$, since both springs have the same extension e.
Also, $k_1 = 2k_2$ (given), so $2x = 1 - x$
$x = 1/3 = 0.33$ m

Ans: C

Q11
Action-reaction forces are equal in magnitude, are oppositely directed, act on two different bodies and are of the same type.

Ans: D

Q12
For the mass of 500 g to move downwards and the mass of 200 g to move upwards, the friction F in the pulley must act opposite to the motion of the masses.
For the masses to move at constant speed, net force = 0. Considering the pulley and masses as a whole, $Mg - F - mg = 0$ or $F = (M - m)g$
$F = (0.500 - 0.200) \times 9.81 = 2.94$ N
Speed of rope = $v = r\,\omega = 0.035 \times 2.4 = 0.084$ m s^{-1}
Hence, rate of work done = $P = F\,v = 2.94 \times 0.084 = 0.25$ W
Since the force exerted by the motor on the rope is opposite in direction to the velocity of the rope, the rate of work done = - 0.25 W

Ans: B

Q13
From graph, $F = kx$ or $4.5 = k\,(0.200 - 0.050) \Rightarrow k = 30.0$ N m^{-1}
By the Law of Energy Conservation, Loss in GPE of load = Gain in elastic PE of spring
$mgx = (1/2)kx^2$ or $0.150 \times 9.81\,(x) = (1/2)\,(30.0)\,x^2$
$x\,(15.0\,x - 1.47) = 0$ or $x = 0.0981$ m = 9.81 cm

So, maximum length attained = 5.0 + 9.81 = 14.8 cm

Ans: C

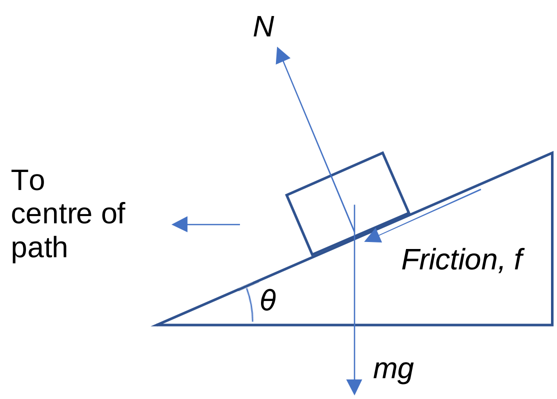
Q14
The spring is shortest when the carts are moving with the same velocity.
By the Law of Conservation of Momentum,
Initial total momentum = Total momentum at instant of common velocity

$(2m)u + m(-u) = (2m + m)V$ taking right as positive direction.
$V = (1/3)u$ = common velocity when spring is shortest.

By the Law of Conservation of Energy,
Gain in elastic PE = Loss in KE = initial total KE – final total KE
$= (1/2)(2m)u^2 + (1/2)mu^2 – (1/2)(3m)V^2$
$= (3/2)mu^2 – (3/2)m\,(u/3)^2$
$= (3/2)mu^2\,(1 – 1/9)$
$= (4/3)mu^2$

Ans: D

Q15



The centripetal force for circular motion is constituted by the sum of the component forces of N and f towards the centre of the circular path. Hence

$$N\sin\theta + f\cos\theta = \frac{mv^2}{r}$$

Ans: B

Q16
$v = r\omega$

$$\omega = \frac{v}{r} = \frac{24.0}{1.2} = 20 \text{ rad s}^{-1}.$$

Ans: A

Q17
The resultant gravitational field on the 1 kg mass is zero. Therefore, $\dfrac{GM_1M_2}{x^2} = \dfrac{GM_2M_3}{(15-x)^2}$

$$\frac{M_3}{M_1} = \frac{(15-x)^2}{x^2} \Rightarrow \sqrt{\frac{16}{9}} = \frac{15-x}{x}$$

$$\frac{4}{3} = \frac{15-x}{x} \text{ or } 4x = 45 - 3x$$

Hence x = 6.4 m

Ans: C

Q18

$a = g = GM/r^2$ is independent of the mass m of the falling body. M is the mass of the earth.

Ans: B

Q19

The p.d. across the $4\,\Omega$ resistor, $V = IR = 1.5 \times 4 = 6.0\,\text{V}$

Hence the current in the $13\,\Omega$ resistor, $I = \dfrac{V}{R} = \dfrac{6.0}{13} = 0.4615$ A

The total current flowing in the internal resistor = $0.4615 + 1.5 = 1.9615\,\text{A}$

Using $P = IV$, we get $V = \dfrac{2.1}{1.9615} = 1.0706 = 1.1$ V

Hence emf = total pd = 3.0 + 6.0 + 1.1 = 10.1 V

Ans: D

Q20

The resistance should start at zero (s = 0), increase in magnitude and then end at zero (s = L).
Let resistance per unit length of the wire be k.
The resistance between X and Y will be that of two resistors in parallel.

Thus $R = \left(\dfrac{1}{R_1} + \dfrac{1}{R_2}\right)^{-1} = \dfrac{R_1 R_2}{R_1 + R_2}$

or $R = \dfrac{(ks)[k(L-s)]}{ks + k(L-s)} = \dfrac{ks(L-s)}{L}$

The variation of R with s is therefore not a straight-line relationship.

Ans: B

Q21

Since the $10\ \Omega$ resistor and $30\,\Omega$ resistor are in parallel, they have the same p.d.

$P_{10\Omega} = \dfrac{V^2}{10}$, $\quad P_{30\Omega} = \dfrac{V^2}{30}$

Hence $\quad P_{10\Omega} = 3 \times P_{30\Omega}$

$\therefore\ \dfrac{P_{10\Omega}}{P_{total}} = \dfrac{3 \times P_{30\Omega}}{3 \times P_{30\Omega} + P_{30\Omega}} = \dfrac{3}{4}$ or $P_{10\Omega} = \dfrac{3}{4} \times P$ while $P_{30\Omega} = \dfrac{1}{4} P$.

Ans: B

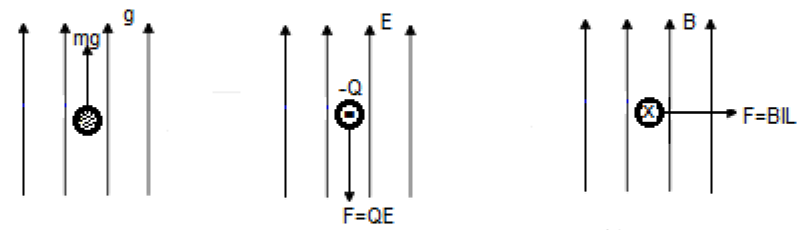
Q22

When connected in series, the same current runs through the resistor and the thermistor. From the graph, we can thus see that the p.d. across the resistor is around 1.2 V and the p.d. across the thermistor is around 3.1 V. This means that the power supply has an emf of 4.3 V.

If we now have the components in parallel with the supply, it means that the p.d. across each component is 4.3 V. Drawing a vertical line at 4.3 V, we see that the current through the resistor is around 0.355 A and the current through the thermistor is around 0.285 A. The total current drawn from the supply is the sum, hence current is 0.64 A

Ans: C

Q23

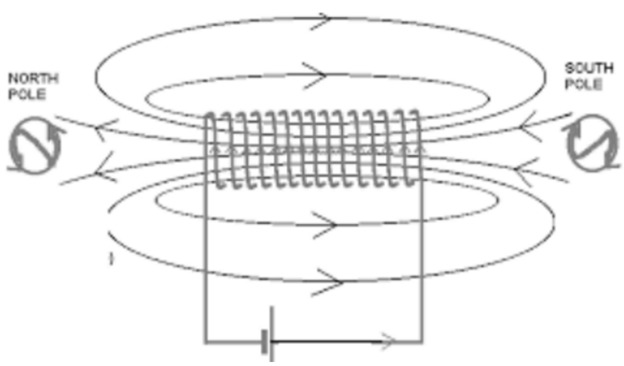


Ans: D

Q24
The currents in the two wires are opposite and hence the two wires repel. The magnitude of the forces acting on each wire is the same by Newton's third law.

Ans: C

Q25



Ans: B

Q26
$F = Eq$ = 3.0 x10^7x1.6 x10^{-19} = 4.8 x10^{-12} N

Ans: A

Q27
Binding energy = mass defect x c^2

= (mass of nucleons – mass of nucleus) x c^2

= [(2 x 1.0087)+ (2 x 1.0073) – 4.0015] x 931 MeV = 28.4 MeV

Ans: A

Q28
Let the parent and daughter nuclei be X and Y respectively. Then

$$ {}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}\beta $$

Hence the atomic number represented by Z increases by 1 unit.

Ans: B

Q29

Ans: C

Q30

In 4 half-lives, the number of nuclei remaining is $\left(\frac{1}{2}\right)^4 N_0 = \frac{1}{16}N_0$. Hence the fraction of N_0 that has decayed after 4 half-lives is $\frac{15}{16}$.

Ans: D

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