PHYSICS

9749

SUGGESTED MARK SCHEME
Maximum Mark: 190

October/November 2022

Paper 1
Multiple Choice

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

1 Since vectors are initially in opposite directions, the initial (*X* – *Y*) yields the largest magnitude, eliminate **B** and **D**

180° means that Y is rotated half-round only, where magnitude of (*X* – *Y*) will not return to original value.

2 took 1 sec for vertical component of velocity to be zero

$$\vec{u} = \vec{u}_x + \vec{u}_y$$

$$\vec{u}_x(t) = s_x$$

$$\vec{u}_x = \frac{s_x}{t} = \frac{50}{1} = 50 \text{ m s}^{-1}$$

$$\vec{v}_y = \vec{u}_y + at$$

$$\vec{u}_y = \vec{v}_y - at = 0 - (-9.81)(1)$$

$$= 9.81 \text{ m s}^{-1}$$

$$\tan\theta = \frac{\vec{u}_y}{\vec{u}_x}$$

$$\theta = \tan^{-1}\left(\frac{9.81}{50}\right)$$

$$= 11.1°$$

3 by conservation of linear momentum

$$m_P(2) + 0 = m_p(-0.5) + m_Q v_Q$$
$$(2.5)m_P = m_Q v_Q \_\_\_\_\_\_ (1)$$

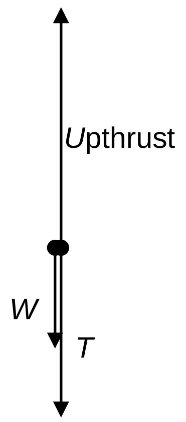
elastic so

$$v_Q - (-0.5) = 2 - 0$$
$$v_Q = 1.5 \text{ m s}^{-1}$$

from (1):

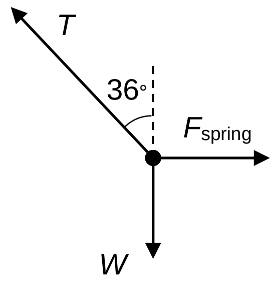
$$\frac{m_P}{m_Q} = \frac{v_Q}{2.5} = \frac{3}{5}$$

4 consider free body diagram of buoy:



$$U = W + T$$
$$T = U - W = \left(\rho_{\text{water}} V_{\text{submerged}} g\right) - mg$$
$$= \left((1030)\left[\frac{1}{2}\left(\frac{4}{3}\pi(0.5)^3\right)\right] - 200\right)(9.81)$$
$$= 683 \text{ N}$$

5 consider free body diagram of mass in translational equilibrium:



horizontally:

$$T\ \sin(36°) = kx = (25)(0.06)$$

vertically:

$$T\ \cos(36°) = W$$
$$W = \left(\frac{(25)(0.06)}{\sin(36°)}\right)\cos(36°)$$
$$= 2.06 \text{ N}$$

6 mean density so assume earth is uniform sphere:

$$|g| = \frac{GM}{r^2}$$
$$\frac{g}{\frac{4}{3}\pi r} = G\frac{M}{\frac{4}{3}\pi r^3} = G\rho$$
$$\rho = \frac{g}{\frac{4}{3}\pi r G}$$
$$= \frac{9.81}{\frac{4}{3}\pi\left(6.37\times10^{6}\right)\left(6.67\times10^{-11}\right)}$$
$$= 5512 \text{ kg m}^{-3}$$

7 by conservation of energy, loss of GPE = work done against air resistance:

$$n = 2$$
$$\text{loss in GPE} = mg\left(h_0 - h_2\right)$$
$$= mg\left(0.6 - 0.6e^{-0.2}\right)$$
$$= (0.4)(9.81)(0.6)\left[1 - e^{-0.2}\right]$$
$$= 0.427 \text{ J}$$

8 all points along a radius have the same angular speed (the *linear* speed of the point on the circumference is the max and the linear speed at the centre is zero)

9 Eliminate **A** and **B** as all geostationary satellites, regardless of their mass, has to be at a fixed distance away from centre of Earth

Eliminate **D**, the satellite will have the same angular velocity as the point on Earth's surface directly below them but the satellite will have far more linear velocity (see reasoning in Q8)

10 gravitational potential is a scalar sum so:

$$\phi_P = \phi_{\text{due to M}} + \phi_{\text{due to 4M}}$$
$$= \left(-\frac{GM}{\frac{d}{2}}\right) + \left(-\frac{G(4M)}{\frac{d}{2}}\right)$$
$$= \frac{-2GM}{d}[1+4] = \frac{-10GM}{d}$$

11 ideal gas so internal energy is purely KE and is directly proportional to thermodynamic temperature:

$$\frac{\text{KE}_{\text{new}}}{\text{KE}_{\text{old}}} = \frac{T_{\text{new}}}{T_{\text{old}}}$$
$$\frac{c_{\text{new}}^2}{c_{\text{old}}^2} = \frac{T_{\text{new}}}{T_{\text{old}}}$$
$$c_{\text{new}} = c_{\text{old}}\sqrt{\frac{T_{\text{new}}}{T_{\text{old}}}}$$
$$= (350)\sqrt{\frac{160+273.15}{80+273.15}}$$
$$= 388 \text{ m s}^{-1}$$

12 ideal gas so internal energy is purely KE and is directly proportional to thermodynamic temperature. Since temperature remains constant, total KE of both initial or final states is same.

$$p = \frac{1}{3}\frac{Nm}{V}c^2$$
$$\frac{3}{2}pV = \frac{1}{2}Nmc^2 = \text{KE}_{\text{total}}$$
$$= \frac{3}{2}(10^5)(0.01)$$
$$= 1500 \text{ J}$$

13 half of KE converted into thermal energy

$$\frac{1}{2}\left(\frac{1}{2}\cancel{m}v^2\right) = \cancel{m}c\Delta T$$
$$\Delta T = \frac{v^2}{4c}$$

14 start with displacement equation and differentiate with respect to time

$$x = x_0\sin(\omega t)$$
$$= x_0\sin\left(\frac{2\pi}{T}t\right)$$
$$= (0.3)\sin\left(\frac{2\pi}{5}t\right)$$
$$v = \frac{dx}{dt}$$
$$= \frac{(0.3)(2\pi)}{5}\cos\left(\frac{2\pi}{5}t\right)$$
$$\approx (0.377)\cos(1.27t)$$

15 **A** because the radio need not be outputting sounds of (driving) frequency which matches that of the natural frequency of the loudspeaker

16 diagram 2 shows frequency

$$f = \frac{1}{T} = \frac{1}{0.2} = 5 \text{ Hz}$$

diagram 1 shows wavelength

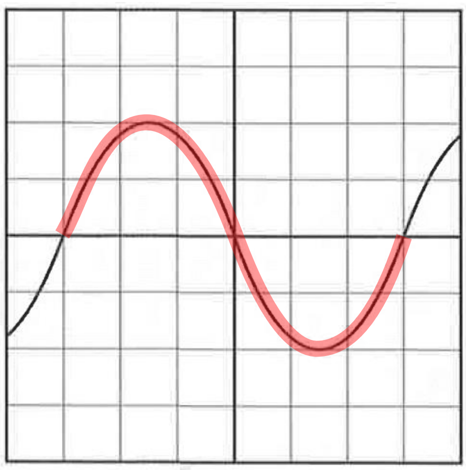
$\lambda = 0.8$ m

$$v = f\lambda = (5)(0.8) = 4 \text{ m s}^{-1}$$

17 stationary wave so XY represents half-wavelength

$$\lambda = 2(5) = 10 \text{ cm}$$

eliminate **A** and **C**



6 divisions on time base gives 1 period

$$T = 6(0.05 \times 10^{-3})$$

$$f = \frac{1}{T} = \frac{1}{6(0.05 \times 10^{-3})}$$

$$= 3333 \text{ Hz}$$

18 double slit experiment so

$$x = \frac{\lambda D}{a} \rightarrow \frac{x}{15} = \frac{\lambda}{a}$$

$$x_A = \frac{700 \times 10^{-9}}{4 \times 10^{-3}} = 0.000175 \text{ m}$$

$$x_B = \frac{20}{50 \times 10^{-3}} = 400 \text{ m}$$

$$x_C = \frac{450 \times 10^{-9}}{2 \times 10^{-3}} = 0.000225 \text{ m}$$

$$x_D = \frac{10 \times 10^{-3}}{200 \times 10^{-3}} = 0.05 \text{ m}$$

19 approach question using kinematics

consider time of flight (time spent inside uniform field)

$$y = vt$$

$$t = \frac{y}{v} \text{ ——— } (1)$$

$$F = qE$$

$$ma = e\left(\frac{V}{d}\right)$$

$$a = \frac{eV}{md} \text{ ——— } (2)$$

$$s = ut + \frac{1}{2}at^2$$

$$x = 0 + \frac{1}{2}\left(\frac{eV}{md}\right)\left(\frac{y}{v}\right)^2$$

20 current along wire is constant so the larger the diameter, the lower the drift velocity, eliminate **C** and **D**

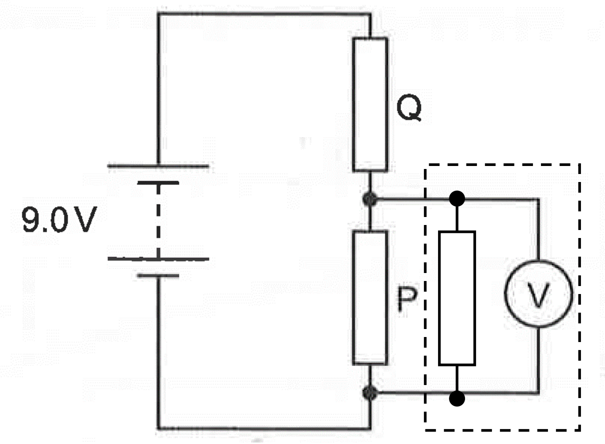
$$I = Anvq$$

$$= (\pi r^2)nve$$

$$= \left(\pi\left(\frac{d}{2}\right)^2\right)nve$$

$$v = \left(\frac{4}{ne\pi}\right)\frac{1}{d^2}$$

21 non-ideal voltmeter can be regarded as its resistance in parallel with an idea voltmeter



$$R_{//} = \frac{R_P}{2}$$
$$I = \frac{V_{//}}{R_{//}} = \frac{2V}{R_P} = \frac{12}{R_P}$$
$$I = \frac{V_Q}{R_Q}$$
$$\frac{12}{R_P} = \frac{3}{R_Q}$$
$$\frac{R_P}{R_Q} = \frac{12}{3} = 4$$

22 e.m.f. of call is 65 cm worth of p.d.

$$\text{e.m.f.} = (65 \times 10^{-2})(14.3)$$
$$= 9.30 \text{ V}$$

23 the forces are N3L pairs, eliminate **B** & **D**

wires attract so current flowing in same direction

24 initially current is normal to B so max value expected with $\theta = 0$, eliminate **A** & **C**

$F = BIL\sin\theta$ so cannot be straight line

25 component of flux normal to area is $B_\perp = B \sin(60°)$

$$\Phi = B_\perp A = BA \sin(60°)$$
$$= (65 \times 10^{-6})(12 \times 10^{-4})\sin(60°)$$
$$= 6.75 \times 10^{-8} \text{ Wb}$$

26 regular square wave so $I_{rms} = I_0$

27 magnetic flux linkage in an a.c. generator is of the form

$$N\phi = NBA \sin(\omega t)$$
$$\frac{dN\phi}{dt} = NBA\omega \cos(\omega t)$$

peak e.m.f. is halved,

new $P = \frac{V^2}{R}$ is $\frac{1}{4}$ of original

original power:

$$P = I_{rms}^2 R$$
$$= \frac{I_0^2}{2} R$$
$$= \frac{4}{2}(20)$$
$$= 10 \text{ W}$$

28 electron has mass, consider:

$$E = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2}$$

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$\frac{\lambda_{\text{new}}}{\lambda_{\text{old}}} = \sqrt{\frac{E_{\text{old}}}{E_{\text{new}}}}$$

$$\lambda_{\text{new}} = \lambda\sqrt{\frac{E}{9E}} = \frac{\lambda}{3}$$

29 mass defect is difference between total mass of individual separate nucleons and mass of nucleus

bismuth isotope has 83 protons and 129 neutrons

$$\Delta m = 83M_{\text{p}} + 129M_{\text{n}} - M$$

30 alpha decay reaction:

$$^{238}\text{U} \rightarrow {}^{234}\text{Th} + {}^{4}_{2}\alpha$$

energy released

$$= \left[\begin{pmatrix}\text{rest mass}\\ \text{of uranium}\end{pmatrix} - \begin{pmatrix}\text{rest mass}\\ \text{of products}\end{pmatrix}\right]c^2$$

$$= (238.1249 - 234.1165 - 4.0026)uc^2$$

$$= 8.67 \times 10^{-13}\ \text{J}$$