DUNMAN HIGH SCHOOL
**2024 PHYSICS H2 (YEAR 5)**

## Suggested Answers to Promotional Exam

### Paper 1

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| C | D | C | B | A | C | A | D | B | D |
| **11** | **12** | **13** | **14** | **15** | | | | | |
| C | D | C | B | A | | | | | |

**1** **C**

The size of a hydrogen atom is around 1 Angstrom or $10^{-10}$ m.

**2** **D**

Student D's value for $g = 8.46 \pm 0.05$ m s$^{-2}$ is far from the actual value of 9.81 but is the most precise of all the students.

**3** **C**

The resultant acceleration is due to the resultant force of air resistance and the weight of the ball

**4** **B**

$N$ and $W_1$ are **not** equal when the woman has non-zero acceleration. (**A** is incorrect.)

($W_1$ + $W_2$) is **not** equal to $T$ when the lift has non-zero acceleration. (**D** is incorrect.)

If $N$ = $W_1$, the woman (thus the lift) can be moving at constant velocity. (**C** is incorrect.)

**5** **A**

Let $m$ be the total mass of the car, the driver and fuel;
$F$ the fixed retarding force;
$\Delta v$ the change in velocity.

Applying Newton's 2nd law of motion to the two situations:

$F = m_1 \dfrac{\Delta v}{t_1}$ --- (1) when the car is almost out of fuel

$F = m_2 \dfrac{\Delta v}{t_2}$ --- (2) when the car has a a full load of fuel

from (1) and (2), we have

$$\left(t_2 - t_1\right) = \left(m_2 - m_1\right)\frac{\Delta v}{F} = \left(130\right)\frac{\left(30-50\right)}{\left(-7000\right)} = 0.37 \text{ s}$$

**6 C**

The wires are slightly elastic hence they can be treated as springs.

The first wire fixed to the wall will experience the same force $F$ and hence will extend by the same length $x$.

The force $F$ is shared equally by the springs in parallel so each spring experiences half the force and extends half as much, $\frac{x}{2}$.

Thus, the total extension is $x+\frac{x}{2}=\frac{3x}{2}$.

**7 A**

Torque = Force multiplied by the perpendicular distance between the line of actions of the two forces.

**8 D**

$$P_{\text{minimum}}=\frac{mg\Delta h}{t}=\left(\frac{m}{t}\right)g\Delta h=\left(\frac{1.3\times10^{9}}{24\times60\times60}\text{ kg s}^{-1}\right)\left(9.81\text{ m s}^{-2}\right)\left(2.0\text{ m}\right)=300\text{ kW}$$

**9 B**

The area under the force-extension graph is the total work done to stretch the material.

**10 D**

The net force acting on the stone when it is vertically below the centre of the circle is given by $T-W=Mr\omega^2$, when $T$ is the tension in the string.

$\therefore T=W+Mr\omega^2$

**11 C**

Gravitational field strength is a vector. It has both direction and magnitude. So C is not true.

**12 D**

The graph shown is an elliptical graph and in simple harmonic motion, the graph of velocity against displacement is elliptical.

**13 C**

When the plasticine is flattened, the surface area increases leading to an increase in air resistance when oscillating. The new system experiences greater damping than before so the new resonance graph is flatter and has the peak shifted slightly to the left.

**14 B**

$$P_X = P_Y \Rightarrow \frac{V_X^2}{R_X} = \frac{V_Y^2}{R_Y} \Rightarrow \frac{R_X}{R_Y} = \frac{V_X^2}{V_Y^2} = \left(\frac{12}{6.0}\right)^2 = 4$$

$$R = \frac{\rho l}{A} = \frac{\rho l}{\frac{\pi}{4}d^2}$$

$$\Rightarrow \frac{d_X^2}{d_Y^2} = \frac{R_Y}{R_X} = \frac{1}{4} \text{ because } l_X = l_Y \text{ and } \rho_X = \rho_Y,$$

$$\therefore \frac{d_X}{d_Y} = \sqrt{\frac{R_Y}{R_X}} = \frac{1}{2}$$

**15 A**

When the potentiometer is balanced (i.e., reading on the galvanometer is zero),
e.m.f. of cell X = p.d. across length QP of the wire

$$\Rightarrow \varepsilon_X = V_{QP}$$

$$\Rightarrow \varepsilon_X = \left(\frac{V_{QR}}{QR}\right)(QP)$$

$$\Rightarrow 0.50 = \left(\frac{2.0}{QR}\right)(QP)$$

$$\Rightarrow (QP) = 0.50\left(\frac{QR}{2.0}\right) = \frac{QR}{4}$$

**Paper 2**

**1** **(a)** kg m$^2$ A1

**(b)** Base units of translational KE = kg m$^2$ s$^{-2}$

[$M$] = kg
[$R^2$] = m$^2$
[$\omega^2$] = s$^{-2$} M1

Base units of rotational KE, $E_{Rotational}$ = kg m$^2$ s$^{-2}$
= Base units of translational KE A0

**(c)**

$$E_{Rotational} = \frac{1}{5}MR^2\omega^2 = \frac{1}{5}\left(36.935\times10^{-3}\right)\left(\frac{20.79\times10^{-3}}{2}\right)^2\left(\frac{2\pi}{1.2}\right)^2$$

$$= 2.188\times10^{-5} \text{ J}$$ A1

$$\frac{\Delta E_{Rotational}}{E_{Rotational}} = \frac{\Delta M}{M} + 2\left(\frac{\Delta R}{R} + \frac{\Delta T}{T}\right)$$ C1

$$= \frac{0.001}{36.935} + 2\left(\frac{0.01}{20.79} + \frac{0.2}{1.2}\right)$$

$$= 0.334$$

$$\Delta E_{Rotational} = 0.334E_{Rotational} = 0.334\left(2.188\times10^{-5}\right) = 0.7\times10^{-5} \text{ J (to 1 s.f.)}$$ A1

$$\therefore E_{Rotational} = (2.2\pm0.7)\times10^{-5} \text{ J}$$ A1

**(d)** Systematic error: A1
Zero error from the micrometer screw gauge / electronic balance

Random error: A1
Human error when starting and stopping the stopwatch

*Marks can be given for other reasonable answers in the context of this experiment*

**2** **(a)** Any two:
- air resistance varies with the speed of the aeroplane
- friction between the aeroplane's wheels and the runway changes (lift reduces normal force on the wheels, decreasing friction with the runway)
- mass of fuel in the aeroplane decreases during take-off B2

**(b)** **(i)** It states that the rate of change in momentum of a body is directly proportional to the resultant force acting on the body and occurs in the direction of the resultant force.

**(ii)** By Newton's 2nd law,
change in momentum of the aeroplane
= area under the graph
= final momentum – initial momentum
= final momentum at take-off – 0 C1

momentum at take-off

$= \left(\frac{1}{2} \times 5.0 \times 1.13 \times 10^5\right) + \left(20.0 \times 1.13 \times 10^5\right) + \left[\frac{1}{2}(1.13 + 0.97) \times 10^5 \times 30.0\right]$ M1

$= 5.693 \times 10^6$

$\approx 5.69 \times 10^6$ N s (to 3 s.f.) A1

**(c)** Using $p = mv$,

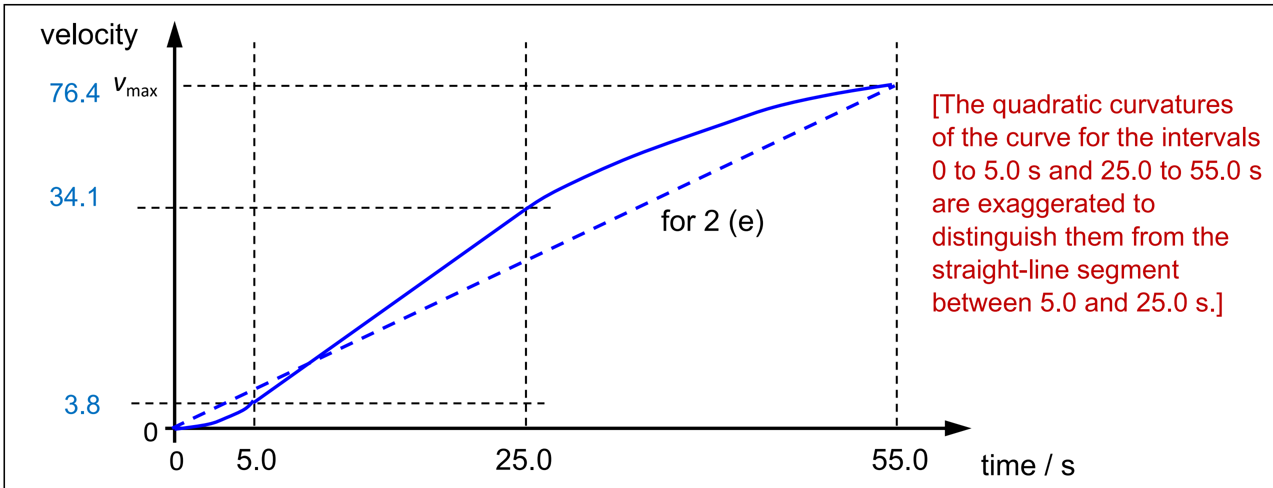
$v_{max} = \frac{p}{m}$

$= \frac{5.693 \times 10^6}{7.45 \times 10^4}$

$= 76.42$

$\approx 76.4$ m s$^{-1}$ (to 3 s.f.) A1

**(d)**




Note:
[1] Curve of increasing gradient from origin and line of constant gradient between 5.0 and 25.0 s.
[1] Line of decreasing positive gradient after 25.0 s.

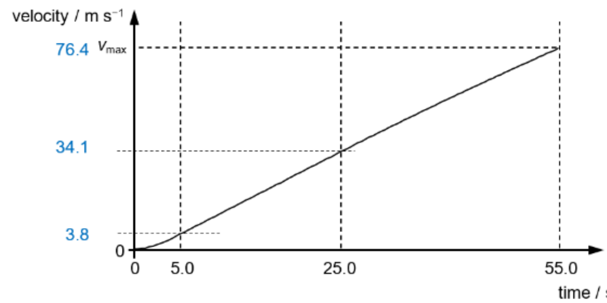
**(e)** Distance = area under graph

$= \frac{1}{2} \times 76.42 \times 55.0$ M1

$= 2101$

$\approx 2200$ m A1

Accept 2050 – 2200 m




(shape of *v-t* graph with correct scales)

**3** **(a)** momentum conservation: $(0.20\text{ kg})(1.8\text{ m s}^{-1}) = (0.50\text{ kg})v$ M1

$v = 0.72\text{ m s}^{-1}$ A1

**(b)** initial KE $= \frac{1}{2}(0.20)(1.8)^2 = 0.32$ J, final KE $= \frac{1}{2}(0.50)(0.72)^2 = 0.13$ J B1

$\because$ final KE < initial KE, $\therefore$ collision is inelastic B1

**(c)**

Change of momentum of 0.20 kg mass

$= (0.20\text{ kg})(0.72 - 1.8) = -0.216\text{ kg m s}^{-1}$

Change of momentum of 0.30 kg mass

$= (0.30\text{ kg})(0.72 - 0) = +0.216\text{ kg m s}^{-1}$

B1

Force on 0.20 kg mass $= \dfrac{-0.216\text{ kg m s}^{-1}}{0.20\text{ s}} = -1.08$ N

Force on 0.30 kg mass $= \dfrac{+0.216\text{ kg m s}^{-1}}{0.20\text{ s}} = +1.08$ N

B1

By Newton's 3rd law, the force acting by 0.2 kg to 0.3 kg is equal and opposite to the force acting by 0.3 kg on 0.2 kg. B1

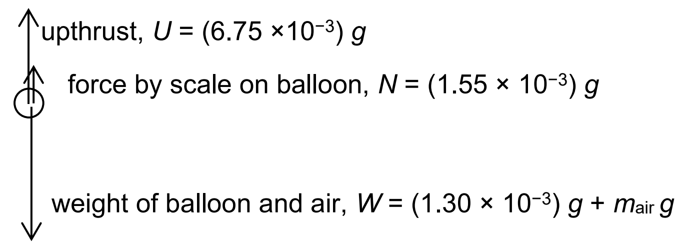
**4** **(a)** Upthrust is the (resultant) upward force exerted by a fluid on a body when it is partially or fully submerged in a fluid. (it is equal in magnitude and opposite in direction to the weight of the fluid displaced.) B1

**(b)** **(i)** $M = \rho V = \rho \times [4/3](\pi r^3)$

$= 1.21 \times [4/3](\pi)(11.0 \times 10^{-2})^3$ C1

$= 0.00675\text{ kg} = 6.75\text{ g}$ A1

**(ii)**



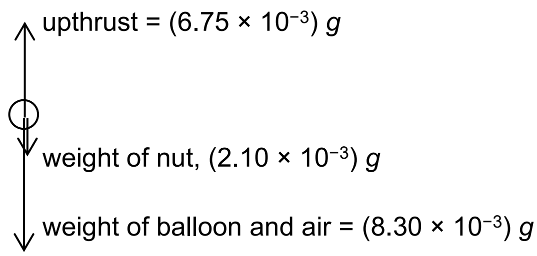

Net force = 0

Thus $1.30 \times 10^{-3}\,g + m_{air}\,g = 6.75 \times 10^{-3}\,g + 1.55 \times 10^{-3}\,g$ C1

Mass of air in balloon, $m_{air}$ = 7.00 g A1

**(iii)** Air is pumped in to inflate the balloon, as such the air inside balloon is compressed, its density is higher compared to the surrounding (uncompressed) air. Since volume is the same, higher density of air in the balloon would mean the mass of the air inside the balloon is higher than the mass of air displaced by balloon. B1

**(c) (i)** At start assume velocity is momentarily zero so drag is zero.




$a = F_{net} / m$

$= [(8.30 + 2.10 - 6.75) \times 10^{-3} \times 9.81] / [(7.00 + 1.30 + 2.10) \times 10^{-3}]$ C1

$= 3.44$ m $s^{-2}$ A1

**(ii)** (When balloon descends, it experiences drag force upwards due to air resistance.)

As speed increases, drag force (upward) increases. M1

(Resultant force (downwards) decreases, acceleration decreases until.)

Acceleration becomes zero when (sum of) upthrust and drag force (upwards) is equal weight of balloon, air and nut. (downwards) A1

**5** **(a)** $\omega = 2\pi f = 2\pi(3.5) = 7\pi$ rad s$^{-1}$ $= 22$ rad s$^{-1}$ A1

**(b)** $y$ (m) $= 0.020\cos(7\pi t)$ A1

**(c)**

$$\begin{aligned} a &= -\omega^2 y \\ &= -484\left[0.020\cos(7\pi t)\right] \\ &= -9.67\cos(7\pi t) \end{aligned}$$ M1

at $t = 2.0$ s,

$$\begin{aligned} a &= -9.67\cos(7\pi \times 2.0) \\ &= -9.67\cos(14\pi) \\ &= -9.67 \text{ m s}^{-2} \end{aligned}$$ A1

The acceleration is directed <u>upward</u>. A1

**(d)** at equilibrium, $mg = ke$ M1

$$k = \frac{mg}{e} = \frac{0.100(9.81)}{0.020} = 49 \text{ N m}^{-1}$$ A0

**(e)** 1 mark for 2 correct answers.

| | gravitational potential energy / J | elastic potential energy / J | kinetic energy / J |
|---|---|---|---|
| lowest point | 0 | $\frac{1}{2}k(2e)^2 = 0.0392$ J | 0 |
| equilibrium position | $Mge = 0.0196$ J | $\frac{1}{2}ke^2 = 0.0098$ J | $\frac{1}{2}Mv_0^2 \approx 0.0097$ J |
| highest point | $Mg(2e) = 0.0392$ J | 0 | 0 |

**6** **(a)** $\text{p.d} = (6.1\text{ V}) \times \dfrac{4.7\text{ k}\Omega}{6.9\text{ k}\Omega}$ B1

$= 4.155\text{ V} = 4.2\text{ V}\ (\text{to 2 sig. fig.})$ A1

**(b)** total resistance, $R_T$, of 4.7 kΩ resistor and voltmeter is given by

$$3.2 = (6.1\text{ V})\left(\frac{R_T}{R_T + 2.2\text{ k}\Omega}\right)$$

$\Rightarrow R_T = 2.4\text{ k}\Omega$ (to 2 s.f.) A1

$\dfrac{1}{2.4\text{ k}\Omega} = \dfrac{1}{4.7\text{ k}\Omega} + \dfrac{1}{R_{\text{voltmeter}}}$ C1

$R_{\text{voltmeter}} = 4.9\text{ k}\Omega$ (to 2 s.f.) A1

**(c)** **(i)** current, $I = \dfrac{0.50\text{ V}}{4.9 \times 10^3} = 1.0 \times 10^{-4}\text{ A}$ (to 2 s.f.) B1

[ECF from **(b)**]

**(ii)**

From $\varepsilon = V + Ir$, where $\varepsilon$ is the e.m.f. of the cell, $r$ its internal resistance, and $V$ the terminal p.d. measured by the voltmeter, we have

$0.93 + \left(\dfrac{0.93}{1.0 \times 10^6}\right)r = 0.50 + \left(\dfrac{0.50}{4.9 \times 10^3}\right)r$ B1

$$0.93 + (9.3 \times 10^{-7})r = 0.50 + (1.0 \times 10^{-4})r$$

$r = \dfrac{0.93 - 0.50}{1.0 \times 10^{-4} - 9.3 \times 10^{-7}} = 4.3\text{ k}\Omega$ A1

**(iii)** $\varepsilon = V + Ir = 0.93 + (9.3 \times 10^{-7})(4.3 \times 10^3) = 0.934\text{ V} \approx 0.93\text{ V}$ A1

**7** **(a)** The force of attraction between two point masses is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. B1

**(b)** **(i)** Gravitational force of attraction on the satellite provides the required centripetal force for the satellite to orbit the Earth. B1

$$\frac{GMm}{r^2} = m\frac{v^2}{r}$$

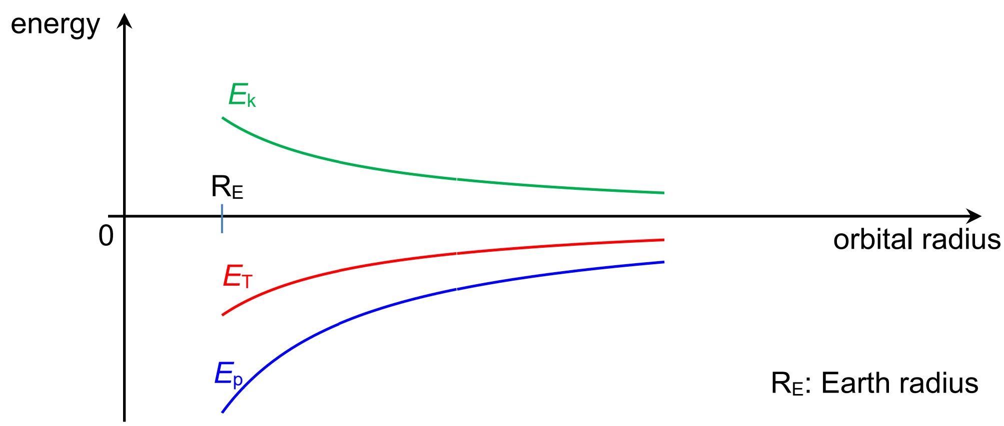
$$\frac{1}{2}\frac{GMm}{r} = \frac{1}{2}mv^2$$

$$-\frac{1}{2}\left(-\frac{GMm}{r}\right) = \frac{1}{2}mv^2 \qquad \text{M1}$$

$$-\frac{1}{2}E_p = E_k \qquad \text{M1}$$

$$E_p = -2E_k \qquad \text{A0}$$

**(ii)**




B1 for $E_K$, $E_T$ and $E_P$ magnitudes
B1 for labeling $R_E$
B1 for $E_K$, $E_T$ and $E_p$ shapes

**(c)** **(i)**

$$\frac{GMm}{r^2} = m\frac{v^2}{r}$$

$$\frac{GM}{r} = v^2$$

$$\frac{(6.67\times10^{-11})(5.98\times10^{24})}{6.70\times10^{6}} = v^2 \qquad \text{C1}$$

$$v = 7720 \text{ m s}^{-1} \qquad \text{A1}$$

**(ii)** At this altitude, the centripetal force provided by the Earth is larger than the required centripetal force (for circular motion at geostationary speed). B1

**(d)** **(i)** Gravitational potential energy is converted into kinetic energy and heat (internal energy) B2

1 mark if KE or heat (internal energy) is omitted.

**(ii)**

$$E_T = -\frac{GMm}{2r} \Rightarrow \frac{\Delta E_T}{E_T} = \frac{\Delta r}{r} = 0.20\%$$ B1

**(iii)**

$$\begin{aligned}\Delta E_T &= \frac{0.20}{100} \times \left(-\frac{1}{2}\frac{GMm}{r}\right) \\ &= -\frac{0.20}{100} \times \frac{1}{2}\frac{\left(6.67\times10^{-11}\right)\left(5.98\times10^{24}\right)\left(1.80\times10^{3}\right)}{6.70\times10^{6}} \quad \text{M1} \\ &= -\frac{0.20}{100} \times 5.3579\times10^{10} \\ &= -1.072\times10^{8}\ \text{J}\end{aligned}$$

Rate of loss of energy of satellite $= \frac{1.072\times10^{8}}{7\times24\times3600} = 177\ \text{J s}^{-1}$ M1

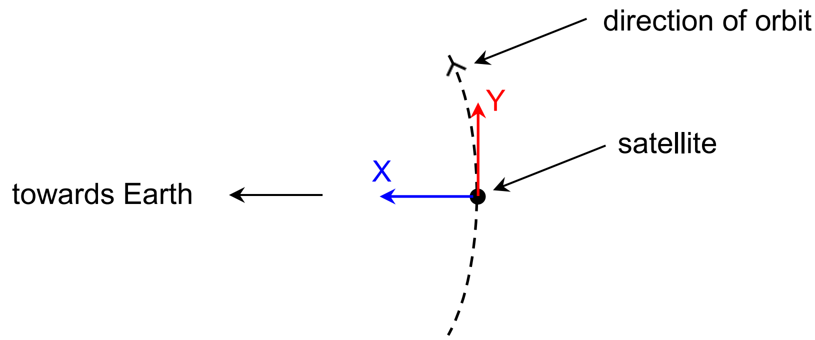
Let $f$ to be the frictional force acting on the satellite,

using $P = Fv$,

we have $177 = f\left(7716\right)$ M1

$f = 0.023\ \text{N}$

**(e)** **(i)** B2




**(ii)**

$$F_Y = uz \Rightarrow$$
$$f = uz$$
$$0.023 = 2.00 \times 10^3 z$$ C1
$$z = 1.15 \times 10^{-5} \text{ kg s}^{-1}$$

Fuel needed for 24 hours $= 24 \times 3600 \times 1.15 \times 10^{-5} = 0.994$ kg A1