EUNOIA JUNIOR COLLEGE
JC1 Promotional Examination 2023
General Certificate of Education Advanced Level
Higher 2

PHYSICS 9749

MARK SCHEME

Sep/Oct 2023

Paper 1
Multiple Choice

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

1 Typical length = 1 m = 100 cm
Typical breadth = 3 cm
Typical height = 0.5 cm

Hence, estimate volume
= 100 × 3 × 0.5
= 150 cm^3

2 **Option A**: Incorrect based on definition of accuracy and precision.
Option B: Checking for zero error prevents systematic error.
Option C:

$t_5 = 5T \Rightarrow \Delta t_5 = 5\Delta T$ vs $t_{20} = 20T \Rightarrow \Delta t_{20} = 20\Delta T$

$\frac{\Delta T}{T} = \frac{\Delta t_5}{t_5} = \frac{\Delta t}{t_5}$ vs $\frac{\Delta T}{T} = \frac{\Delta t_{20}}{t_{20}} = \frac{\Delta t}{t_{20}}$

Note:
1. The uncertainty for a stopwatch timing is fixed, whether it is timing 5 or 20 osc. Hence $\Delta t_5 = \Delta t_{20} = \Delta t$.
2. Since $t_5 < t_{20}$, fractional uncertainty of T is smaller when the number of osc is larger.

Option D:
Compare 1 vs 4 measurements, take uncertainty of the instrument as Δd
Case 1 (1 measurement): d_1
$\Delta d = \Delta d$
Case 2 (4 measurements): d_1, d_2, d_3, d_4

$$d_{ave} = \frac{d_1 + d_2 + d_3 + d_4}{4}$$

$$\Rightarrow \Delta d_{ave} = \frac{\Delta d + \Delta d + \Delta d + \Delta d}{4} = \Delta d$$

Hence taking more measurements to find average has no impact on uncertainty.

3 Using v^2 = u^2 + 2as
70^2 = 40^2 + 2(a)(300)
a = 5.5 m s^{-2}

4 Taking downward as positive:

$s = ut + \frac{1}{2} at^2$
$5 = 0 + \frac{1}{2}(9.81)\, t^2$
$t = 1.00964$

Consider the horizontal:
$s_x = v_x \times t$
$= 0.8 \times 1.0$
$= 0.8$ m

5 The sandbag is travelling upwards with a velocity of 4.0 m s^{-1} when it is first released. Hence the displacement of the sandbag will increase in the upwards direction before it eventually starts falling (since acceleration of the sandbag is 9.81 m s^{-2} downwards).

Since s is defined as the displacement of the sandbag from the point of release, $s = 0$ at the point of release.

6 **Method 1: Each mass is a different system**

$$m_1 g - T = m_1 a \qquad (1)$$
$$T - m_2 g = m_2 a \qquad (2)$$

$(1)+(2)$:
$$(m_1 - m_2)g = (m_1 + m_2)a$$
$$a = \frac{(m_1 - m_2)g}{(m_1 + m_2)}$$

Method 2: Both masses belong to the same system

Mass of system= $(m_1 + m_2)$
Net force on system = $(m_1 g - m_2 g)$

Acceleration of the two objects,
$$F_{net} = ma$$
$$m_1 g - m_2 g = (m_1 + m_2)a$$
$$a = \frac{m_1 g - m_2 g}{m_1 + m_2}$$

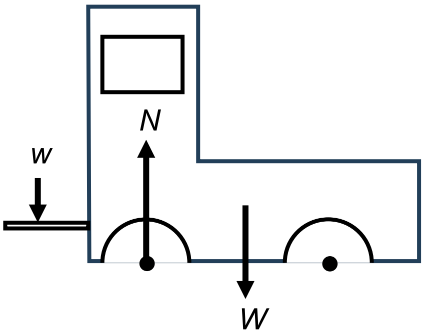
7 Since total momentum before the collision is 0, total momentum after the inelastic collision should also be 0.

Total kinetic energy before the collision is 27 J. Since <u>collision is inelastic</u>, total kinetic energy after collision should be less than 27 J.

Students who thought KE = 0 <u>assumed incorrectly</u> that it was a <u>perfectly inelastic</u> collision.

8 At equilibrium, let U be the amount of upthrust required to balance the weight W of the vehicle.
$$W = U$$
$$m\cancel{g} = V\rho\cancel{g}$$
$$2.0\times10^4 = (4\times12.5\times h)\times1000$$
$$h = 0.40 \text{ m}$$

9 **Method 1:**
To find force on chassis at front axle, take moment about the rear axle. Let N be the normal contact force by the front axle on the truck.



By principle of moments,
Initially, load w is not present:

$$W(x) = N(2x)$$
$$N = \frac{W}{2}$$

Finally, let N' be the new contact force of the front axle on the truck when w loaded:

$$W(x) + w(3x) = N'(2x)$$
$$N' = \frac{W + 3w}{2}$$

Hence contact force of front axle on truck increases by $\frac{3w}{2}$.

Method 2:
With w loaded, there is an additional anti-clockwise moment $w(3x)$ about the rear axle. This must be counter-balanced by the extra clockwise moment provided by the extra contact force ΔN of the front axle.

$$w(3x) = \Delta N(2x)$$
$$\Delta N = \frac{3w}{2}$$

10 Using Hooke's Law, tension is directly proportional to extension.

When tension is T, extension is $(x - L)$.
When tension is T', extension is $(y - L)$.

$$\frac{T'}{T} = \frac{(y-L)}{(x-L)}$$
$$T' = \frac{T(y-L)}{(x-L)}$$

11 2 engines of 80% efficiency provides power for the plane. Let P be the power for each engine, then

$$(80\%)(2P) = Fv$$
$$(0.8)2P = (200000)(250)$$
$$P = 31.3 \times 10^6 \text{ W } = 31.3 \text{ MW}$$

12 For first 3.0 s, acceleration is constant at 9.81 m s^{-2} since drag is insignificant.

Given $v = at$, $E_K = ½mv^2 = ½ma^2t^2$
i.e. E_K is a quadratic function in t.

Once parachute opens, air resistance increases tremendously and net force is upwards. Hence velocity falls and E_K falls.

Eventually, parachutist will reach terminal velocity and kinetic energy reaches a constant value.

13 **Method 1:**
Tension provides the centripetal force.

When radius of circle is $L+e$,
extension = e

$$ke = \frac{m_1 v^2}{L+e}$$
$$v^2 = \frac{ke(L+e)}{m_1} \qquad (1)$$

When radius of circle is $2(L+e)$,
extension = $L+2e$

$$k(L+2e) = \frac{m_2 v^2}{2(L+e)}$$
$$v^2 = \frac{2k(L+e)(L+2e)}{m_2} \qquad (2)$$

Equate (1) and (2):

$$\frac{ke(L+e)}{m_1} = \frac{2k(L+e)(L+2e)}{m_2}$$

$$m_2 = \frac{2\cancel{k}(L+e)(L+2e)m_1}{\cancel{k}e(L+e)} = \frac{2m_1(L+2e)}{e}$$

Method 2: Proportionality Method
Tension (Elastic force provides the centripetal force.)

$$F = ke = m\frac{v^2}{r}$$

$m \propto re$ since k, v are constant

$$\frac{m_2}{m_1} = \frac{r_2}{r_1}\cdot\frac{e_2}{e_1}$$
$$m_2 = \frac{2m_1(L+2e)}{e}$$

14 Resultant of tension and weight provides the centripetal force

At top:

$$mL(2\pi f)^2 = T_{top} + mg \qquad (1)$$

At bottom:

$$mL(2\pi f)^2 = T_{bot} - mg \qquad (2)$$

(2) – (1)

$T_{top} - T_{bot} = 2mg$

15

$$g = \frac{GM}{r^2} \Rightarrow g \propto \frac{1}{r^2} \Rightarrow \frac{g_2}{g_1} = \left(\frac{r_1}{r_2}\right)^2$$

$$\therefore \frac{10}{5} = \left(\frac{x}{r}\right)^2 \Rightarrow r = \frac{x}{\sqrt{2}}$$

where r is the radius of earth

16 **Option A: incorrect**
The period of an equatorial satellite can be a geostationary satellite (period 24 h) if the radius is correct

Option B: correct
Determine formula for kinetic energy

$$\frac{GMm}{R^2} = \frac{mv^2}{R}$$
$$\frac{GMm}{2R} = \frac{mv^2}{2}$$
$$E_K = \frac{GMm}{2R}$$

When R increases, E_K decreases

Option C: incorrect

$$\frac{GMm}{R^2} = mR\omega^2 = mR\left(\frac{4\pi^2}{T^2}\right) \Rightarrow T^2 = \frac{4\pi^2 R^3}{GM}$$

T independent of m
(Can also use Kepler's law ($T^2 \propto r^3$) here though it is not officially in syllabus and equation must be proved if used in P2 & P3)

Option D: incorrect

Total Energy = $E_P + E_K = -\dfrac{GMm}{2R}$

When M increase, total energy decreases (becomes a more negative number)

17 A **uniform gravitational field** has a constant gravitational field strength in a uniform direction. i.e. same magnitude and same direction (along the direction of the gravitational force). The direction of the field lines is the direction of motion of a test mass released in it. The gravitational potential at each point may vary.

18 Since kinetic energy is max at t = 0 s, the mass started at the equilibrium position, and the x-t graph is a sine graph, v-t graph is a cosine graph, and a-t graph is a negative sine graph.

From given E-t graph:

$$T = 0.800 \text{ s} \quad \Rightarrow \quad \omega = \frac{2\pi}{T} = 7.85$$

$\Rightarrow$ Eiminate A & C

$$E_{max} = \frac{1}{2} m v_o^{\,2}$$

$$2.0 = \frac{1}{2}(0.50) v_o^{\,2}$$

$$v_o = 2.83 \text{ m s}^{-1}$$

$$\therefore \quad v = v_o \cos(\omega t) = 2.83 \cos(7.85t)$$

$$\& \quad a = -\omega x_0^2 \sin(\omega t)$$

$$= -v_o x_0 \sin(\omega t)$$

$$= -22.2 \sin(7.85t)$$

19

$$\omega = \frac{v}{r} = \frac{2.0}{0.40} = 5 \text{ rad s}^{-1}$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{5} = 1.26 \text{ s} \Rightarrow \frac{1}{4}T < 0.40 \text{ s} < \frac{1}{4}T$$

$$x = x_o \cos \omega t = (0.40)\cos(5(0.40)) = -0.17 \text{ m}$$

$$\text{distance travelled} = 0.40 + 0.17 = 0.57 \text{ m}$$

20 No damping occurs in a vacuum, in contrast to a small amount of damping in air. Hence at natural frequency of the pendulum, maximum amplitude increases.

21 Phase difference

$$\frac{\Delta s}{\lambda} \times 2\pi = \frac{0.22 \times \sin 25^\circ}{1.7} \times 2\pi = 0.34 \text{ rad}$$

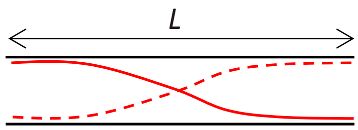
22 Speed of wave,

$$v = f\lambda = \left(\frac{1}{T}\right)\lambda = \frac{1}{2 \times 10^{-3}}(0.6) = 300 \text{ m s}^{-1}$$

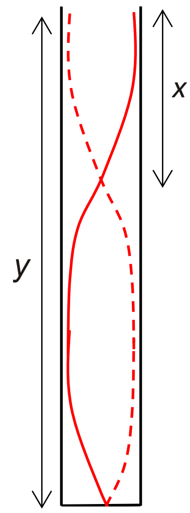
23 It is crucial to note that the θ in the diagram is <u>not</u> between the polarisation axis of the 2 polarisers.
At θ = 0 , π, 2π…, transmission axes of the 2 polarisers are perpendicular ⇒ no light passes through both polarisers, intensity of the transmitted light is zero.
At θ = 0.5π, 1.5π…, transmission axes of the 2 polarisers are parallel ⇒ all light passes through both polarisers, intensity of the transmitted light is maximum.

24 Initially, path difference is zero and constructive interference occurs, giving rise to the high amplitude signal. The next time constructive interference occurs is when the path difference is 8.4 cm, λ. To obtain an increase distance of 8.4 cm, the slider only has to move 4.2 cm as the top part of the slider will contribute 4.2 cm and bottom part of the slider will contribute 4.2 cm.

25 For the **open tube**, the resonant mode of sound wave produced will have a wavelength ***λ* = 2*L***.



The air column inside the burette then resonates with sound at the **same frequency**, at the appropriate lengths:



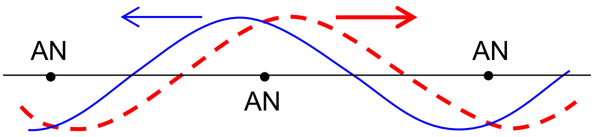
The difference between x and y would correlate to half wavelength.
Hence

$$y - x = \frac{\lambda}{2} = L$$

26 Two waves with identical
- frequencies,
- amplitudes and
- speeds

travelling opposite to each other will **always** form a stationary wave where they overlapped.

Consider the case as the waves moves in the directions as specified in question, then:



At **position X**, the wave would have **maximum amplitude of 2A at some point in time**, where A is the amplitude of each wave. Hence it is an **antinode.** (Another way to see it: the mid-point between any peak of one wave and the neighbouring peak (of the same displacement direction) of the second wave will always be an antinode.)

At **position Y**, the wave will be non-zero amplitude, but is neither node or antinode.

At **position Z**, the wave will be always have **zero amplitude** and is a **node.**

27 Along PQ, a stationary wave is formed, distance between consecutive maxima is $\frac{\lambda}{2}$.

Time taken to travel between maxima is $\frac{1}{f}$

Speed in m s^{-1} = $\frac{v \times 10^3}{60 \times 60} = \frac{5v}{18}$

Using distance travelled = speed $\times$ time

$$\frac{\lambda}{2} = \frac{5v}{18} \cdot \frac{1}{f}$$

$$\lambda = \frac{5v}{9f}$$

28

$$d \sin\theta = n\lambda$$

$$\frac{1}{N} \sin\theta = n\lambda$$

When $\theta = 90°$,

$$\frac{1.0 \times 10^{-3}}{300} \sin 90° = n\left(450 \times 10^{-9}\right)$$

$$n = 7.4$$

Total of bright spots = 7 + 7 +1 = 15
(Each side has 7 spots, plus 1 central maxima)

29 Putting info in diffraction grating formula:

$$d \sin\theta = 2\lambda_X = 3\lambda_Y$$

$$\frac{\lambda_X}{\lambda_Y} = \frac{3}{2}$$

30 Wavelength of visible light is in the range 400 – 700 nm. Use 550 nm for calculation as an estimation.

Using small angle approximation and Rayleigh's criterion:

$$\frac{s}{r} \approx \theta \approx \frac{\lambda}{b}$$

$$\frac{1.4}{r} = \frac{(550 \times 10^{-9})}{(5 \times 10^{-3})}$$

$$r = 13 \text{ km}$$