DUNMAN HIGH SCHOOL
2021 PHYSICS H2 (YEAR 5)

Answers to Mid-Year Exam

Section A

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

1 B

Airbus A330: 870 km h^{-1}
Boeing 737-300: 780 km h^{-1}

2 B

Let the top mark be *a* and lower mark be *b*.
Let the time the ball passes the top mark be t_a and when it passes the lower mark, t_b.

Hence the speed v of the ball is $v = \frac{b-a}{t_b - t_a} = \frac{270}{2.00}$

$$\frac{\Delta v}{v} = \frac{\Delta b + \Delta a}{b-a} + \frac{\Delta t_b + \Delta t_a}{t_b - t_a} = \frac{2\text{ mm}}{270\text{ mm}} + \frac{0.04\text{ s}}{2.00\text{ s}} = \frac{2}{270} + \frac{0.04}{2.00}$$

3 B

The gradient of the displacement-time graph gives the velocity.
Car M is accelerating as it has an increasing velocity (since gradient increases).
Car N is not accelerating as it has a constant velocity (since gradient is constant).
Statement is incorrect.

4 C

$s = ut + 0.5at^2$
For 1st half,
$0.5L = 0.5at_1^2$ --- (1)
For entire journey,
$L = 0.5aT^2$ --- (2)
Solve (1) and (2)
$t_1 = 0.71T$

5 B

By Newton's 3rd Law of Motion, action and reaction forces are equal in magnitude and opposite in direction and they act on different bodies.

6 **C**

From Newton's 2nd Law of Motion,

$T - mg = ma$ (1)

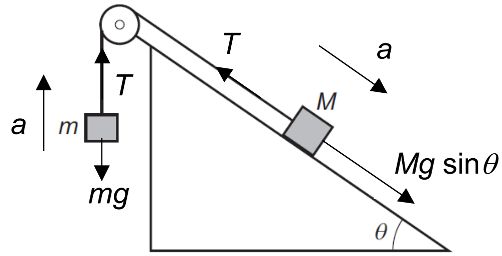
$Mg \sin\theta - T = Ma$ (2)

Adding the equations gives

$Mg \sin\theta - mg = (m + M)a$

Since the right hand side is positive, then $Mg \sin\theta - mg > 0$

or $\sin\theta > m/M$



7 **A**

The corresponding extension of spring is shown on graph.

From graph,

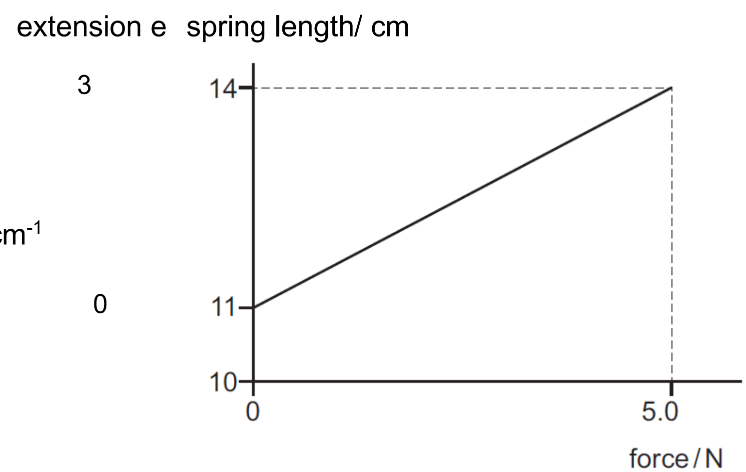
spring constant $k = F/e = 5/3$ N cm^{-1}

When force = 7 N,

$F = ke$

$7 = (5/3)\ e$

so extension e = 4.2 cm



8 **A**

Since all cuboids are fully submerged, volume of displaced water is the volume of cuboid which is the same for all cuboids. Since upthrust is the volume displaced water x density of water x g, upthrust is the same on all cuboids.

9 **B**

Gain in GPE = 400 x 9.81 x 1200 = 4.7 MJ

Power output = Work/time = 4.7 x 10^6 / 120 = 39kW

Power input = 39/0.8 = 49kW

10 C

Since body is moving up the track with constant velocity, there is no change in its K.E.

power supplied = rate of increase in G.P.E. + rate at which work is done against the resistive forces

$$= \frac{mg(\Delta h)}{t} + \frac{Fd}{t}$$

=7.0(9.81)(20 sin 30°) +12(20)

= 930 W

11 D

minimum tension occurs at the top:

$$T_1 + W = m\frac{v^2}{r} = (0.30)\frac{5.0^2}{0.60} = 12.5 \text{ N}$$

$$\Rightarrow T_1 = 9.6 \text{ N}$$

maximum tension occurs at the bottom:

$$T_2 - W = m\frac{v^2}{r} = 12.5$$

$$\Rightarrow T_2 = 15.4 \text{ N}$$

12 D

$$\frac{\text{force on the Earth due to the Moon}}{\text{force on the Earth due to the Sun}}$$

$$= \frac{G\frac{M_m M_E}{r_m^2}}{G\frac{M_S M_E}{r_S^2}} = \frac{M_m}{M_S}\left(\frac{r_S}{r_m}\right)^2$$

13 D

for points outside the Earth of mass M,

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

at the point a distance x from Earth's centre:

$$5 = \frac{GM}{x^2} \text{ ----- (1)}$$

at the surface of Earth of radius R,

$$10 = \frac{GM}{R^2} \text{ ----- (2)}$$

$$\frac{(1)}{(2)} \Rightarrow \frac{1}{2} = \frac{R^2}{x^2} \Rightarrow R = \frac{x}{\sqrt{2}}$$

14 C

gravitational potential, $\phi = -\frac{GM}{r}$

$\Rightarrow \phi$ is inversely proportional to r

$\Rightarrow \phi_Y r_Y = \phi_X r_X \Rightarrow \phi_Y = \phi_X \frac{r_X}{r_Y} = \left(-8 \text{ kJ kg}^{-1}\right)\frac{L}{2L} = -4 \text{ kJ kg}^{-1}$

$\phi_Y - \phi_X = \left(-4 \text{ kJ kg}^{-1}\right) - \left(-8 \text{ kJ kg}^{-1}\right) = +4 \text{ kJ kg}^{-1}$

$U_Y - U_X = m\left(\phi_Y - \phi_X\right) = 1 \text{ kg}\left(+4 \text{ kJ kg}^{-1}\right) = +4 \text{ kJ}$

15 A

$G\frac{Mm}{r^2} = mr\omega^2$

$\Rightarrow G\frac{M}{\omega^2} = r^3 \Rightarrow r = \left[\frac{GM}{\omega^2}\right]^{\frac{1}{3}}$

Section B

1 (a) (i) check for zero error (on micrometer)/zero the micrometer [B1]

(ii) take readings along the length of the wire/at different points and take average value [B1]

(iii) take readings spirally/around the wire at the same point and take average value [B1]

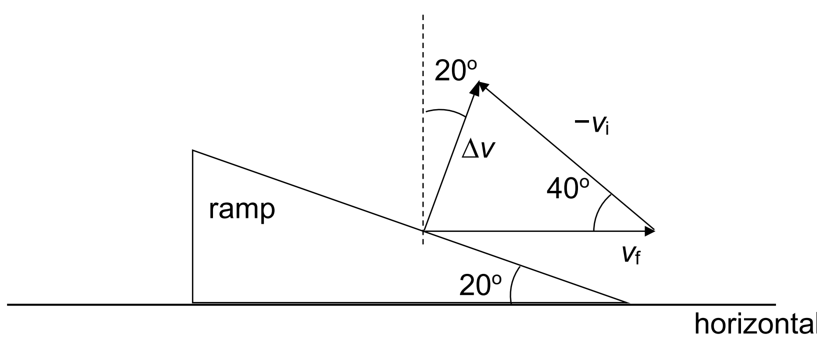
(b) unit of D = [units of k] [units of d]
units of k = 1 [A1]

unit of Q = [units of C] [units of ρ] [units of $\sqrt{g}$] [units of $(D - kd)^{3/2}$] [M1]

kg s^{-1} = [units of C] (kg m^{-3}) (m $s^{-2})^{1/2}$ $(m)^{3/2}$
units of C = m [A1]

Comments: Mass flow rate is the mass of a substance which passes per unit of time, Its unit is kg s^{-1} in SI units. However, many quoted its unit to be m s^{-1}. Many also failed to see that terms D and kd must have the same units as they are combined using subtraction.

(c)



Determining the direction of Δv using $\Delta v = v_f - v_i$ [M1]
Since Δv is 90° to the surface of the ramp, Δv is 70° with respect to the horizontal [A1]

cosine rule: [M1]

$$(\Delta v)^2 = v_f^2 + v_i^2 - 2v_f v_i \cos 40^\circ = 5.0^2 + 5.0^2 - 2(5.0)(5.0)\cos 40^\circ$$

$$\Delta v = 3.4 \text{ m s}^{-1}$$ [A1]

*Comments: Quite a number drew the vector diagram for Δ**v** incorrectly as **v**f +**v**i, instead of **v**f + (–**v**i). Graphical method to determine Δ**v** is acceptable.*

2 **(a)** The projectile undergoes a trajectory symmetrical about the centre (or parabolic trajectory), with vertical displacement $\underline{s_y = 0}$. [B1]

Taking upwards as positive and considering vertical motion,

$$s_y = u_y t_o + \frac{1}{2} a t_o^2$$

$$0 = (u \sin\theta) t_o - \frac{1}{2} g t_o^2 \qquad \text{[C1]}$$

$$t_o = \frac{2u \sin\theta}{g} \quad \text{(shown)}$$

<u>Alternative method:</u>

Since the projectile undergoes a parabolic trajectory,

Taking upwards as positive and considering vertical motion,

Vertical component of initial velocity, $u_y = u \sin\theta$ [C1]

Vertical component of final velocity, $v_y = -u \sin\theta$

$$v_y = u_y + a t_o$$

$$-u \sin\theta = u \sin\theta - g t_o \qquad \text{[C1]}$$

$$t_o = \frac{2u \sin\theta}{g} \quad \text{(shown)}$$

<u>Alternative method:</u>

Taking upwards as positive and considering vertical motion of the projectile,

At the highest point of its trajectory, vertical component of velocity, $v_y = 0$

$$v_y = u_y + at$$

$$0 = u \sin\theta - gt \qquad \text{[C1]}$$

$t = \dfrac{u \sin\theta}{g}$ where t is the time taken for it to reach the peak of its trajectory

Since the projectile undergoes a parabolic trajectory, its total flight time is twice the time taken to reach the peak of its trajectory.

$$t_o = 2t \qquad \text{[C1]}$$

$$= \frac{2u \sin\theta}{g} \quad \text{(shown)}$$

Comments: Most students can prove it using one of the 3 methods mentioned.

(b) horizontal displacement of projectile = horizontal displacement of cart + 45 m

or $(u\cos\theta)t = vt + 45$ [C1]

$$v = u\cos\theta - \frac{45}{t}$$

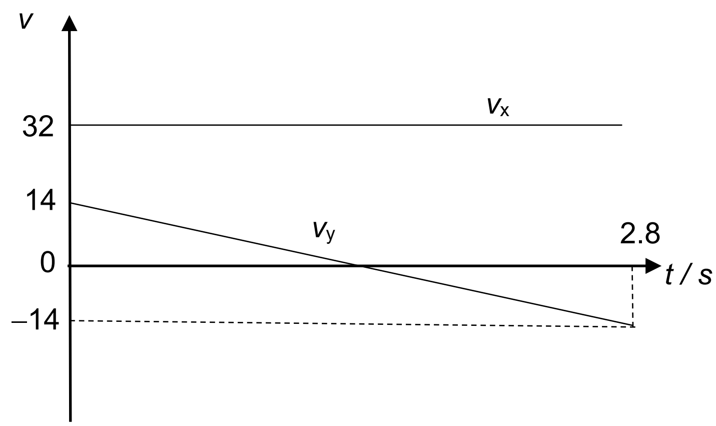
$$= u\cos\theta - 45\left(\frac{g}{2u\sin\theta}\right)$$

$$= 35\cos 23° - 45\left(\frac{9.81}{2\times 35\sin 23°}\right)$$ [M1]

$$= 16.08 = 16.1 \text{ m s}^{-1}$$ [A1]

Comments: Some students will forget to minus 45 from displacement, or add 45 instead.

(c)



For each graph, shape [1 m], values [1 m]

Comments: Some students left numerical values as 35 cos 23 / sin23. It is preferred to calculate them out. Some mixed up vx and vy, others did not read question and did not include any values. For all sketches it is recommended to include values if they are known.

(d) Launch the projectile with a larger speed or lauch the projectile at a larger angle to the horizontal. (but less than 45°) [B1]

Comments: Some suggested lowering angle, thinking the projectile will fly further. Some suggested slower speed since larger speed causes more air resistance. It is best to think simple and just launch it faster to overcome air resistance.

3 **(a)** **(i)** mass is the property (of a body/object) which resists changes in motion [B1]

Comments: answers to be referenced from syllabus learning outcome.

(ii) The total momentum of a system of interacting bodies is constant [B1]

provided no resultant external force acts on the system. [B1]

Comments: Note that the principle can also be applied to non-collision problems.

(b) **(i)** force on A (by B) equal and opposite to force on B (by A)

or both A and B exert equal and opposite forces on each other [B1]

force is rate of change of momentum <u>and</u> time (of contact) is same [B1]

(ii) $(3M \times 0.40) - (M \times 0.25) = (3M \times 0.2) + Mv$ [C1]

$v = 0.35\ \text{m s}^{-1}$ [A1]

Comments: Momentum is a vector and hence negative sign for opposite direction of velocity.

(iii) **1.** relative speed of approach = 0.40 + 0.25 = 0.65 m s^{-1} [A1]

2. relative speed of separation = 0.35 – 0.20 = 0.15 m s^{-1} [A1]

(iv) (relative) speed of separation not equal to (relative) speed of approach or answers to **(b)(iii)** are not equal **and** so inelastic collision [B1]

4 **(a)** $\rho = m/V$ [C1]

$V = \pi d^2 L/4 = \pi r^2 L$ [C1]

$W = mg = 2.7 \times 10^3 \times \pi(1.2 \times 10^{-2})^2 \times 5.0 \times 10^{-2} \times 9.81$ [C1]

$= 0.60$ N [A0]

Comments: As this is a "show" question, it is important to show all steps of the working with the appropriate substitution of the values.

(b) **(i)** 1. no resultant force or sum of forces is zero. [B1]

2. no resultant moment/torque or sum of moments/torques is zero. [B1]

(ii) $12W = (0.25 \times 8) + (0.6 \times 38)$ [C1]

$W = 2.1$ N [A1]

Comments: Some students make mistakes in converting the length in cm to m in the calculation of moments. This conversion is not necessary and the mistake can be avoided.

(c) **(i)** pressure increases with depth (in water) or pressure on bottom of cylinder <u>greater than</u> pressure on top [B1]

difference in pressure created a net upward force as the force (up) on bottom of cylinder <u>greater than</u> force (down) on top [B1]

The net upward force is the upthrust on the cylinder. [A0]

Comments: Answers need to explain why there is a difference in pressure and link this difference in pressure to the net upward force which is the upthrust.

(ii) anticlockwise moment reduced and reducing the weight of X reduces clockwise moment or
anticlockwise moment reduced so clockwise moment now greater than (total) anticlockwise moment [B1]

Comments: It is incorrect to say upthrust create additional clockwise moment or clockwise moment increase due to upthrust. Upthrust acts on the cylinder and does not act on the bar AB.

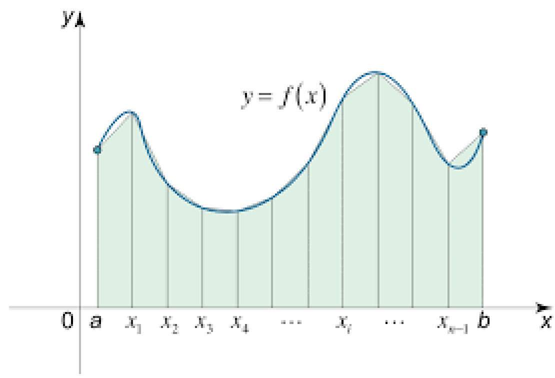
5 **(a)** Evidence of use of area below the line [C1]

Distance = area under the graph

= ½ (6+5.7)(2) + ½ (5.7 + 5.1)(2) + ½ (5.1+3)(4) = 39 m [A1]

Allow 39 ± 0.5 m (if greater than 1 but less than 2 m, allow 1 mark of the two)

Comments: Some students counted squares, which is not recommended. Using trapeziums is best, see example below. Some students used kinematics instead, not realizing kinematics can only be used for constant acceleration.



(b) **(i)** [A1]

$$\Delta K.E. = \frac{1}{2}m(v_f^{\,2} - v_i^{\,2}) = \frac{1}{2}(95)(3^2 - 6^2) = -1280 \text{ J}$$

Comments: Many students dropped the -ve sign, however the sign is very important because it tells us whether the bicycle gained or lost KE.

(ii) $\theta = \sin^{-1}(1/30) = 1.91^\circ$ [M1]

Δ GPE = $mg\Delta h$ = (95)(9.81)(39 sin1.91°) = 1210 J [A1]

Values will vary based on answer in (a)

Comments: Some student thought gain in PE = loss in KE. Others thought the 30m was horizontal distance, but it is actually slant distance.

(c) Energy delivered to the bicycle = gain in GPE + gain in KE + energy used to overcome resistive forces. [C1]

Energy used to overcome resistive forces = (75 × 8) – 1210 + 1280 = 670 J [A1]

Comments: Very poorly answered, few had any idea how to answer. Students should learn to write out the conservation of energy equation and not try to reinvent physics all the time.

(d) **(i)** (Gradient of the graph gives acceleration of the cyclist and bicycle.)
The acceleration starts off at zero and increases in magnitude. [B1]

Comments: Poorly answered. Many said acc decreases due to downward slope, however the focus should be on the magnitude. Students also mentioned acceleration increased/decreased with increasing/decreasing rate. Students should not try to write unnecessary statements, especially when it is not possible to tell if the acceleration actually increased with a increasing/decreasing/constant rate, i.e. can only tell that the gradient increased, but can't tell if the gradient increased constantly or not.

(ii) Since air resistance decreases as speed decreases and the component of the weight along the slope is constant, [M1] hence that the driving force by the cyclist upslope must be decreasing [A1] with time so that the net force/acceleration downslope will have an increasing magnitude.

Comments: Extremely poorly answered. Students need to consider how all forces changed, but many only mentioned air resistance or net force but not both. Net force increased, while air resistance decreased, which then leads to conclusion that driving force must decrease.

6 **(a)** For a body moving with uniform speed in a circle, its direction of motion changes constantly with time, and thus its velocity is always changing [B1]. By Newton's first law, a force [B1] must be acting on it.
Since the change in velocity at every instant is directed towards the centre of the circle [B1], the acceleration, and hence, by Newton's second law, the force is directed towards the centre of the circle.

(b) **(i)** $\omega = \dfrac{175 \times 2\pi}{60} = 18.3 \text{ rad s}^{-1}$ [A1]

(ii)

$$T = Mg = 0.90 \times 9.81 = 8.829 \text{ N}$$

$$\text{resultant force} = \sqrt{T^2 - (mg)^2}$$

$$= \sqrt{8.829^2 - (0.30 \times 9.81)^2} \quad \text{[C1]}$$

$$= 8.32 \text{ N} \quad \text{[A1]}$$

Comments: Alternatively, many calculated the angle θ made by the string with the vertical using T cos θ = mg, and obtained the resultant force using T sin θ.

(iii)

$$\text{resultant force} = mr\omega^2 \quad \text{[C1]}$$

$$r = \frac{8.32}{0.30 \times 18.3^2} = 0.0826 \text{ m} \quad \text{[A1]}$$

(iv) It would not be possible [A1] for the string to be horizontal because the string needs to make an angle with the horizontal such that there is a vertical component of the tension to balance the weight [M1].