DUNMAN HIGH SCHOOL
2022 PHYSICS H2 (YEAR 5)

Answers to Mid-Year Exam

Section A

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

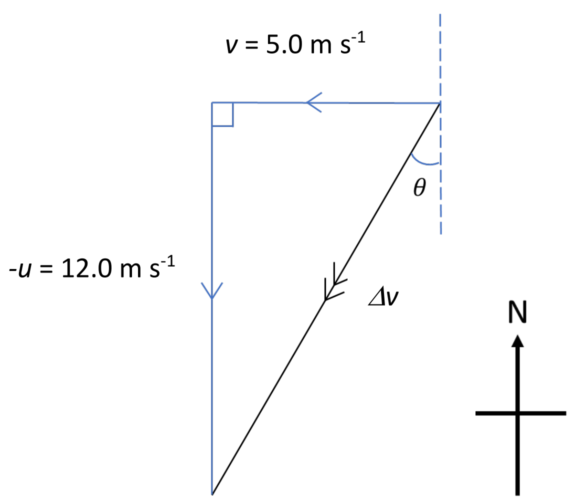
1 C

$$\sigma = \frac{P}{AT^4}$$

$$\text{Units of } P = \frac{kg\, m\, s^{-2} \times m}{s} = kg\, m^2\, s^{-3}$$

$$\text{Units of } \sigma = \frac{kg\, m^2\, s^{-3}}{m^2\, K^4} = kg\, s^{-3}\, K^{-4}$$

2 D



$$\text{Change in velocity} = \text{final velocity} - \text{initial velocity}$$

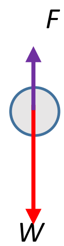
$$\Delta v = v - u = v + (-u)$$

$$\text{Magnitude of } \Delta v = \sqrt{5.0^2 + 12.0^2} = 13\, \text{m s}^{-1}$$

$$\theta = \sin^{-1}\left(\frac{5}{13}\right) = 23°$$

The change in velocity is 13 m s^{-1} at a direction 23° West of South

3 **C**



During fall in air, *weight of ball W - viscous force F = ma*

The ball viscous force increases with speed, hence acceleration decreases.

At terminal speed, net force is zero, hence $W = F$

If mass m is less, terminal speed is less.

At sufficiently large t, the $s-t$ graph is a straight line as the gradient of $s-t$ graph gives the velocity. Answer is C.

4 **B**

$$\begin{aligned} v_y &= u_y + at \\ &= -8 + 1.62(9) \\ &= 6.58 \text{ ms}^{-1} \end{aligned}$$

$$\begin{aligned} \text{speed } &= \sqrt{v_y^2 + v_x^2} \\ &= \sqrt{6.58^2 + 4^2} \\ &= 7.7 \text{ ms}^{-1} \end{aligned}$$

5 **C**

Considering the free body diagram of the measuring device,

$$T - 5(9.81) = 5(3)$$
$$T = 64 \text{ N}$$

6 **B**

The component of the weight along the slope = (12) (9.81) sin 20° = 40 N

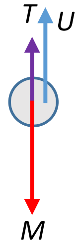
Hence resultant force = 200 – 40 = 160 N

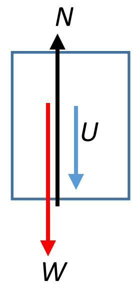
7 **D**

Normal reaction acts perpendicularly (normally) to the surface.

8 **D**

Consider free body diagram of

the mass 

the beaker of water 

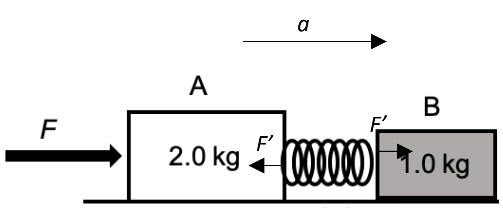
$T + U = M$ -----(1)

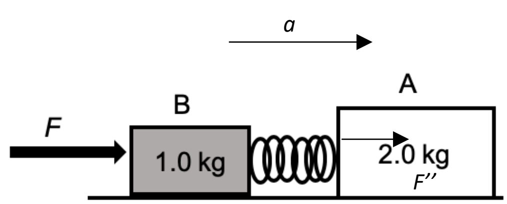
$N = W + U$ ------(2)

From (1), $U = M – T$

Hence, $N = W + M - T$

9 **A**





F = ma = (2.0 + 1.0) a

$a = F / 3$

$F' = kx_1 = F / 3$

$x_1 = F / 3k$

$F'' =F/3 \times 2$

$kx_2 = 2F/3$

$x_2 = 2F / 3k = 2 x_1$

$\Rightarrow x_1 : x_2 = 1 : 2$

10 **A**

pressure $p = \rho gh$

$$= \left(600 \text{ kg m}^{-3}\right)\left(9.81 \text{ m s}^{-2}\right)\left(20.0 \times 10^{-2} \text{ m}\right)$$

$$= 1.18 \times 10^{3} \text{ Pa}$$

11 C

work done, $W = Fs\cos\theta$
$= (2.1\text{ N})(4.0\text{ m})\cos 30^\circ$
$= 7.3\text{ J}$

12 A

constant $v = 30\text{ m s}^{-1} \Rightarrow$ zero resultant force

equation of motion down the slope:

$F_{engine} + mg\sin 6^\circ - 2000 = 0$

$\Rightarrow F_{engine} = 2000 - 1500(9.81)\sin 6^\circ = 461.9\text{ N}$

power output of the car's engine $= F_{engine}v = 13856\text{ W} = 14\text{ kW}$

13 D

$$v_{actual} = \left(\frac{50}{2}\right)\omega = 25\omega,\quad v_{indicated} = \left(\frac{60}{2}\right)\omega = 30\omega$$

$$\Delta v = v_{indicated} - v_{actual} = +5\omega$$

$$\frac{\Delta v}{v_{actual}} = \frac{+5}{(50/2)} = +20\%$$

14 B

$$\frac{1}{4}T = 4 \times 0.250\text{ s}$$

$$T = 4 \times 4 \times 0.250 = 4.00\text{ s}$$

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{4.00} = 1.571\text{ rad s}^{-1}$$

$$a = r\omega^2 = (0.500)(1.571)^2 = 1.23\text{ m s}^{-2}$$

15 A

Like an external resultant force, the centripetal force is NOT an additional force acting on the object. It should not be drawn on any free-body diagrams.

Section B

1 **(a)** Density is defined as mass per unit volume. [B1]

Comments: "mass *over* volume" not accepted.

(b) vernier calipers [B1]

(c) percentage uncertainty = $\frac{\Delta r}{r}\times 100\% = \frac{0.0004}{0.0420}\times 100\% = 0.95\%$ [A1]

Comments: As absolute uncertainty is given to 1 s.f., the percentage uncertainty should be recorded to 1 s.f. or at most 2 s.f.

(d) **(i)** $\rho = \frac{Mr^n}{kL}$

units of LHS = kg m^{-3}
units of RHS = kg (m^n) (m^{-1}) [M1]

Comparing indices, -3 = n – 1 [M1]
Thus n = -2 [A0]

Comments: Some students were very poor in their presentation, and some wrongly equated physical quantities with units e.g. "*M* = kg"

(ii)

$$\rho = \frac{Mr^n}{kL}$$

$$\frac{\Delta\rho}{\rho}\times 100\% = (\frac{\Delta M}{M} + 2\frac{\Delta r}{r} + \frac{\Delta L}{L})\times 100\%$$ [C1]

percentage uncertainty
= [(0.001)/(1.072) + (2)(0.0004)/(0.0420) + (0.0001)/(0.1242)] x 100%
= 2.1% [A1]

(iii) ρ = (1.072) $(0.0420)^{-2}$ / [(2.094) (0.1242)] = 2336.7 kg m^{-3} [C1]
$\Delta\rho$ = (0.021) (2336.7) = 50 kg m^{-3} (1.s.f) [C1]
ρ = (2340 ± 50) kg m^{-3} [A1]
= (234 ± 5) x 10^1 kg m^{-3}

Comments: Some students calculated this by finding the maximum or minimum possible value of ρ. As long as the working is clear, this method is also given full credit.

2 **(a)** Speed is a physical quantity and cannot be defined by a unit (seconds). [B1]
Speed is distance travelled per unit time. [B1]

Comment: Very few stated that speed is a physical quantity. Instantaneous speed or average speed were quoted as having the definition of "distance travelled per second".

(b) **(i)** Method 1: Using equations of motion

Taking downwards to be positive: [M1]

$v^2 = u^2 + 2as = 1.5^2 + 2(9.81)(0.65)$

$v = \pm 3.9 \text{ m s}^{-1}$

Final speed = 3.9 m s^{-1} [A1]

OR

Method 2: Using conservation of energy

Loss in GPE = Gain in KE [M1]

$mgh = \frac{1}{2}m\left(v^2 - u^2\right)$

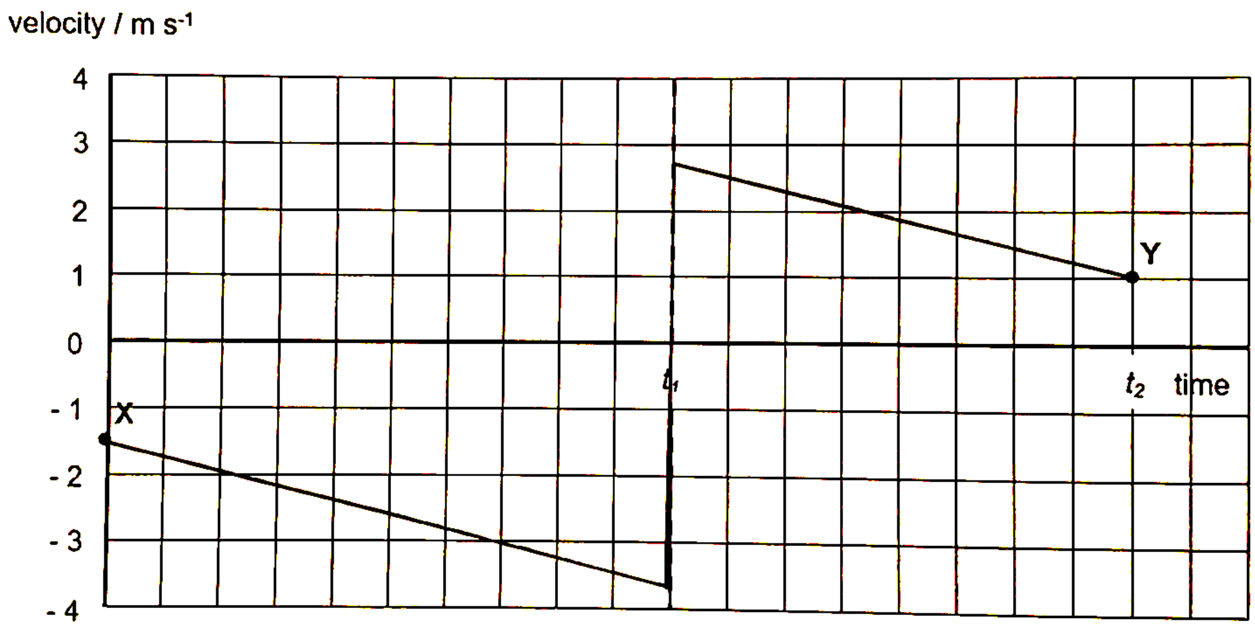
$v^2 = 2gh + u^2$

$v = 3.9 \text{ m s}^{-1}$

Final speed = 3.9 m s^{-1} [A1]

Comment: Method 1 is the common method used for this part which were well done.

(ii)



Straight line from X to t_1 [B1]

Straight line from X to - 3.9 m s^{-1} [B1]

Gradient straight line from t_1 to t_2 must be parallel to line from 0 to t_1. [B1]

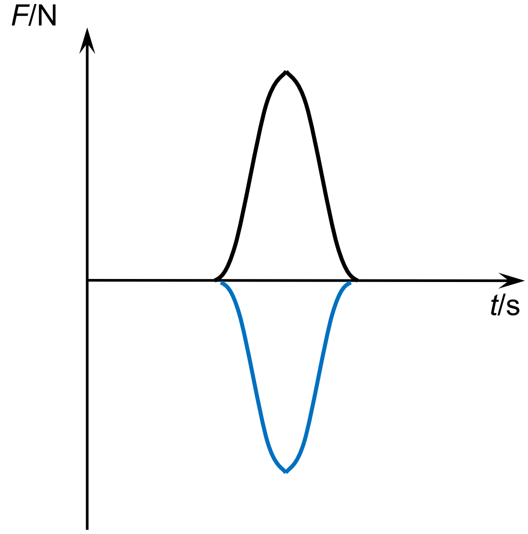
Comment: A few drew curves for this part. The straight line drawn from t_1 to t_2 is not parallel to the line drawn from 0 to t_1.

(iii) The speed of the ball after **rebound is less than the speed just before impact**. The ground/Earth is assumed to be stationary, hence there is a **loss in the kinetic energy of the system** during the bounce. [B1]

Hence the bounce is **not elastic.** [B1]

Comment: The system of Earth and ball was not stated. Many only mentioned kinetic energy was not conserved but did not specify whether it was the kinetic energy of ball or system. Some mentioned bounce was elastic but the explanation contradicted with the answer.

3 **(a)(i)** [B1]



Comments: Care must be given to ensure that the graph is symmetrical about the horizontal axis. At the very least, the amplitude must be correct. This question was marked leniently and many answers were given BOD even though the graph drawn wasn't symmetrical.

(a)(ii) The principle of conservation states that the total momentum in a system is constant if no net force acts on the system. [B1]

The negative and positive areas represent the changes in momentum (or impulses) of the two trucks. [B1]

By Newton's third law, they are equal and opposite in direction, hence the total change in momentum for the two-trucks system is zero. [B1]

Hence total momentum of system is constant. [A0]

Comments: This question requires you to make reference to (a)(i).

(b)(i) take original direction of big truck to be +ve

By Conservation of Momentum,

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ [C1]

$3mv + m(-v) = 3m(0.60v) + mv_2$

$v_2 = 0.20v = 0.20 \times 70 = 14 \text{ km h}^{-1} = 3.9 \text{ m s}^{-1}$ [A1]

in the original direction of big truck

Comments: Several candidates failed to convert km h^{-1} to m s^{-1}.

(b)(ii) Mass of small truck = 5 000 kg

$14 \text{ km h}^{-1} = 3.9 \text{ m s}^{-1}$, $70 \text{ km h}^{-1} = 19.4 \text{ m s}^{-1}$

Average force = impulse / time

= m(v – u) / t [C1]

= 5 000 (3.9 – (–19.4)) / 1.2

= 97 200 N (3 s.f.) [A1]

(c) Impulse is the product of the average force and time of impact. For the same change in momentum hence same impulse, the crumpling effect lengthens the duration of impact, hence lowers the average impact force. [B1]

Comments: Answers which did not make reference to impulse e.g. using energy considerations, are not given any credit. Also, some students have a misconception and mentioned about reduced impulse; but impulse is constant in this case. Lastly, the correct explanation is the ***average force*** **(not just *force*)** is reduced because of lengthened impact duration.

4 **(a)** The moment of a force about a point is defined as the product of the force and the perpendicular distance [B1]
from the point to the line of action of the force. [B1]

Comment: The system of Earth and ball was not stated. Many only mentioned kinetic energy was not conserved but did not specify whether it was the kinetic energy of ball or system. Some mentioned bounce was elastic but the explanation contradicted with the answer.

(b)(i) By Newton's second law,

$T_{AB} - mg = ma$ [C1]

$$T_{AB} = 300(1.0) + 300(9.81)$$
$$= 3243 = 3240 \text{ N}$$ [A1]

Comment: Whether to use negative or positive sign for the acceleration posed a problem for most answers.

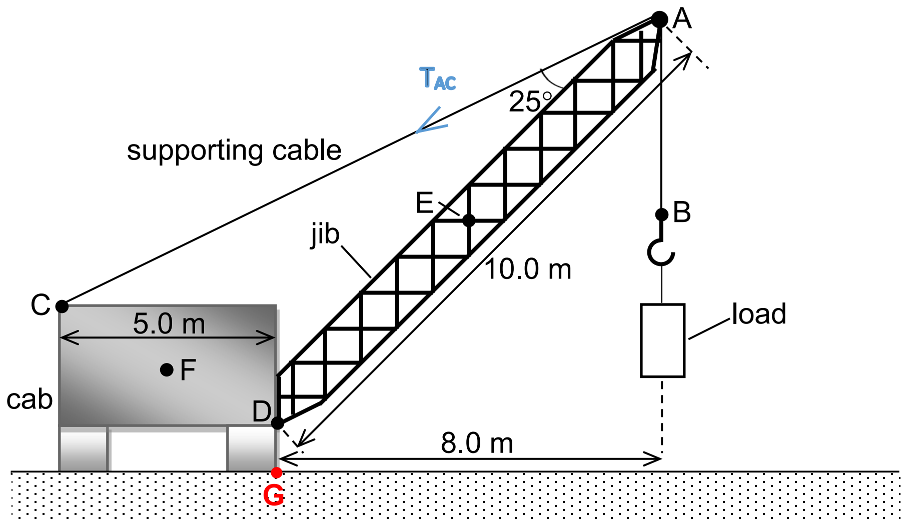
(b)(ii) Consider the forces on the jib.
Since the jib is in equilibrium, taking moments about D,
sum of anticlockwise moments = sum of clockwise moments

$$(T_{AC} \sin 25°)(10.0) = 2400(9.81)(4.0) + 3240(8.0)$$ [C1]

$$T_{AC} = 28417 = 28400 \text{ N}$$ [A1]

Comment: Resolution of tension or distance, taking and equating moment of the forces were a challenge. Most did not score well for this part.

(c)(i)



[B1]

(c)(ii) When the crane is just about to topple about G, the normal contact force on the left wheel just goes to zero.

Considering the forces on the crane and taking moments about G,
sum of anticlockwise moments = sum of clockwise moments

$$16000(9.81)(2.5) = 2400(9.81)(4.0) + W_{max}(8.0)$$ [C1]

$$W_{max} = 37278 = 37300 \text{ N}$$ [A1]

Comment: Only a few got it right for this part. The point where the crane was just about to topple was not indicated on the diagram or a wrong point was chosen.

(d) The force by the wind on the slab will cause it to swing/ sway/ oscillate. [B1]

This results in additional clockwise moment from the increased tension in cable AB as the slab is displaced rightwards by the wind,
OR increased perpendicular distance from G when wind is blowing such that the slab sways away from the crane, [B1]

hence it will topple clockwise about G. [A0]

Comment: Very few saw the increase in tension in cable AB. Increase in perpendicular distance from the pivot was the common answer given. Key words like the concrete slab swings or sway was missing in the description of motion of the slab.

5	**(a)**	gravitational potential energy is energy of a mass due to its position in a gravitational field	**B1**
		elastic potential energy is the energy stored (in an object) due to (a force) changing its shape / deformation / being compressed / stretched / strained	**B1**
		Comment: Qualitative descriptions should be given, instead of merely quoting the formulae.	
	(b)	**(i) 1.** Initial kinetic energy = $\frac{1}{2} m u^2$	**C1**
		$= \frac{1}{2} \times 0.065 \times 16^2 = 8.3(2)$ J	**A1**
		2. $0^2 = u^2 - 2gh$ OR increase in GPE (mgh) = decrease in kinetic energy ($\frac{1}{2} m u^2$)	**C1**
		$h = u^2 / 2g = 16^2 / (2 \times 9.81) = 13(.05)$ m	**A1**
		(ii) $v = u + at$ At time t, $0 = 16 - 9.81\, t$ $t = 1.63$ s At $t/2$, $v = 16 - (9.81)(1.63 / 2) = 8$ m s^{-1}	**C1**
		Comment: If using $h = u\,t + \frac{1}{2}(-g)\,t^2$ to find t, the quadratic equation also has two real identical roots of $t = 1.63$ s because the discriminant is equal to zero.	
		Method 1 $KE_{max} = \frac{1}{2} m (16)^2$ At $t/2$, $KE = \frac{1}{2} m (8)^2$ $= \frac{1}{4} KE_{max}$ And $PE = \frac{3}{4} KE_{max}$	**C1**
		Thus ratio = $(\frac{3}{4}) / (\frac{1}{4}) = 3$	**A1**
		Method 2 At $t/2$, $h' = u\,(t/2) + \frac{1}{2}(-g)\,(t/2)^2$ $= 16\,(0.815) + \frac{1}{2}(-9.81)(0.815)^2$ $= 9.78$ m	**C1**
		Thus ratio = $[m\,g\,h'] / [\frac{1}{2} m (8)^2] = [m\,(9.81)(9.78)] / [\frac{1}{2} m (8)^2] = 3$	**A1**

Comment: Note that at $t/2$, $h' \neq h/2$ but $h' = \frac{3}{4}h$. Therefore, the ratio is also given by $h'/(h - h') = 3$.

(iii) average acceleration is greater OR average force is greater **M1**

[$0 = u - \langle a_y \rangle t$ or $t = u / \langle a_y \rangle$]

hence, time is less **A1**

Comment: Note that there is no upward force acting on the ball after it has been thrown vertically upwards. Both its weight and air resistance act downward to exert a greater downward average force on the ball.

6	**(a)**	constant speed or constant magnitude of velocity	**B1**
		acceleration (always) perpendicular to velocity	**B1**
	(b)(i)	$F = mv^2 / r$	**C1**
		$F = 790 \times 94^2 / 318$ $= 22\ 000$ N	**A1**

(b)(ii)

	Y less than X	Y same as X	Y greater than X	
centripetal acceleration		✓		**B1**
maximum speed			✓	**B1**
time taken for one lap of the track			✓	**B1**

Comment:
1. since $a = F / m$, X and Y has the same a because they have the same F and m
2. since $v = \sqrt{ar}$, Y has greater v as it has greater r
3. since $T = 2\pi/\omega = 2\pi/(a/v) = 2\pi v/a$, Y has greater T as it has greater v

	(c)	**(i)** point S at the lowest point on the circle	**B1**
		Comment: For a particular ω, the tension T in the glue varies sinusoidally and is maximum when the stone is at the lowest point of the circular motion. As ω is gradually increased from zero, T increases at all positions of stone and T will first reach the value of 18 N (for the glue to snap) when the stone is the lowest point on the circle.	
		(ii) (max) force / tension – weight = centripetal force $18 - 3 = mr\omega^2 = (3.0 / 9.81)(0.85)\,\omega^2$ $\omega = 7.6$ rad s^{-1}	 **C1** **A1**
		Comment: Many did not consider the weight of the stone for the resultant centripetal force. Another common mistake was writing the equation as (max tension – weight) = $r\omega^2$ without the mass m.	