H2 Physics 2025 Timed Trial Solutions

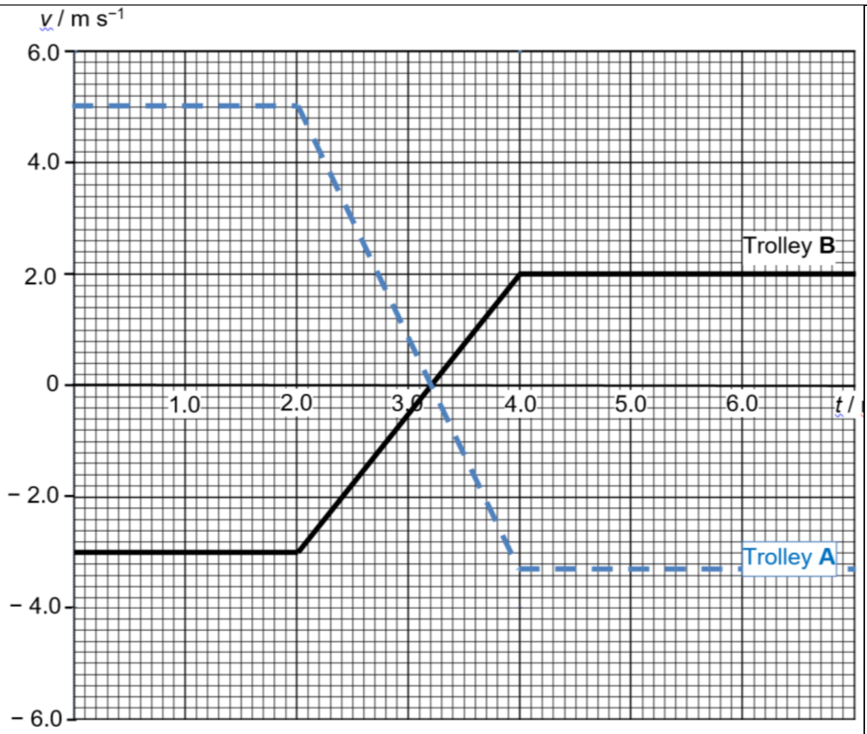
1 (a)	$\sin 5^0 = \frac{h}{458}$ h = 39.91 = 39.9 m Note: COE & kinematics equations are unaccepted. **Examiner's Comments:** • Some students erroneously wrote $v_y^2 = u_y^2 + 2a_ys_y$, where $28^2 = 0 + 2(9.81)s_y$. This is totally inappropriate although the answer yielded happens to be 39.9 m. • Some erroneously applied the COE method, saying that the total initial energy = $KE_i + GPE_i$ = 0 + 0, and total final energy = ½ (800)(28^2) + (800)(9.81)(h). Total initial energy is simply not equal to the total final energy in this case! There is unknown energy input from the car's motor.	[1]
(b)	Taking downwards as positive, from the cliff top to the ground, $s_y = u_yt + \frac{1}{2}a_yt^2$ 39.91 = (-28 sin 5°) t + ½ (9.81) t^2 (ecf for wrong h) t = 3.11 s or -2.61 s (NA) **Examiner's Comments:** • Many made careless mistakes in substitution (esp negative signs) because they did not consider a certain direction as positive. • Some students neglected "sin 5°" in u_y. • Some took a lengthy method to find the time taken for different parts of the flight path and then adding them up. But some students only calculated the time for part of the flight path. • Note that v_y is not zero at the ground!	[1, ecf] [1]
(c)	By conservation of energy, taking the 'start' point to be at the <u>edge of cliff</u>, 10% of total mech energy of car before impact = KE remaining after impact $0.1\left(mgh + \frac{1}{2}mv^2\right) = \frac{1}{2}mu^2$ 0.1 [(9.81)(39.91) + ½ (28^2)] = ½ u^2 (ecf for wrong h) u = 12.51 = 12.5 m s^{-1} **Alternatively**, taking the 'start' point to be at <u>just before touching</u> the <u>ground</u> (hence GPE = 0), 10% of KE (just before touching ground) = KE remaining after impact 0.1 x ½ (m)(v^2) = ½ (m)(u^2)	[1, ecf] [1]

	where speed just before touching ground is $v = \sqrt{v_x^2 + v_y^2}$ = 39.58 where v_x = 28 cos 5° , and v_y has to be solved using $v_y = u_y + a_y t$ = (-28 sin 5°) + (9.81)(3.11) = 28.09 m s^{-1} **Examiner's Comments:** • There are different ways to solve this question, depending on where you see the 'start' point as. • Many students forgot to include either the initial KE or GPE at the 'start' point on the LHS of the eqn above. • Some erroneously wrote "90%" instead of "10%" in the eqn above.	
(d)	Taking rightwards as positive, $v^2 = u^2 + 2as$ $0 = 12.51^2 + 2(-2.5)s$ s = 31.3 m Total distance = 86 m + 31.3 m = 117 m, which is greater than 100 m. The car will collide with the wall. **Alternatively**, $v = u + at$ 0 = 12.51 + (-2.5)(t) $t = \frac{12.51}{2.5}$ = 5.004 s From $s = ut + \frac{1}{2}at^2$ s = (12.51 x 5.004) + ½ (-2.5)(5.004^2) (ecf for wrong u) = 31.3 m **Alternatively**, Taking rightwards as positive, $v_x^2 = u_x^2 + 2a_x s_x$ $= 12.5^2 + 2(-2.5)(14)$ v_x = 9.31 m s^{-1} Since the speed at the wall is not zero, car will collide with the wall. , **Alternatively**, Kinetic energy left after impact in (c) = ½ mu^2 = ½ x 800 x 12.51^2 = 62600 J Work done needed to decelerate car to a stop = (ma) x s = (800 x 2.5) x (100 – 86) = 28000 J. Since the initial kinetic energy is more than the work done required to bring the car to a **stop at the wall**, the car will have some more energy to move beyond the wall. **{ Principle: Change in KE = Work Done by Net Force}**	[1, ecf] [1]

	Examiner's Comments: • Some students drew a *v*-*t* graph to find the time for braking and distance travelled during braking (area of graph). This is also allowed. • 2nd mark is only awarded if there was a valid/ logical reasoning based on correct physics. • Some students erroneously compared the 'time needed for deceleration' with the 'time taken during constant speed motion'.	

2(a) (i)1.	By conservation of momentum, $\rightarrow$: $m_A u_A + m_B u_B = m_A v_A + m_B v_B$ 6.0 (5.0) + 10 (-3.0)= 6.0 (v_A) + 10 (2.0) v_A = - 3.33 m s^{-1} speed = 3.3 m s^{-1} **Examiner's Comments:** • Some students forgot to consider account of the signs when subbing in the velocities as they forgot momentum is a vector.	 [1] [1]
2.	KE before collision: KE_i = ½ (6)(5)^2 + ½ (10)(3)^2 = 120 J KE after collision: KE_f = ½ (6)(3.3)^2 + ½ (10)(2)^2 = 53 J Since there is a loss in kinetic energy during the collision, the collision is inelastic. **Examiner's Comments:** • Some students use the relative speed of approach = relative speed of separation method which is acceptable if they did not mixed up the terms. However if student used this method, the signs of the velocities must be taken into account. • Students are advised to present their answers properly. They should not present in such a way that KE before and after are equal and then later has a line that shows the number does not tally. They should calculate KE before and after separately then compare the two. Such poor presentation may be penalised for the A levels.	[1] [1]

(ii)1.



[2]

Correct shape (starting and ending point of the slope, straight lines) – [1]
Correct values – [1]
Allows ECF from part (a)

Examiner's Comments:

- Most students got this correct. Concept is that the total momentum before collision = total momentum after collision. 2 to 4 ms is the duration of the collision.
- Some number of students forgot to that the final velocity is negative as (a)(i)1 ask for speed of A after collision.

2.

For B,
Force = d(mv)/dt
= 10(2 –(-3))/ (2.0 x 10^{-3}) [1]
= 25 000 N [1]

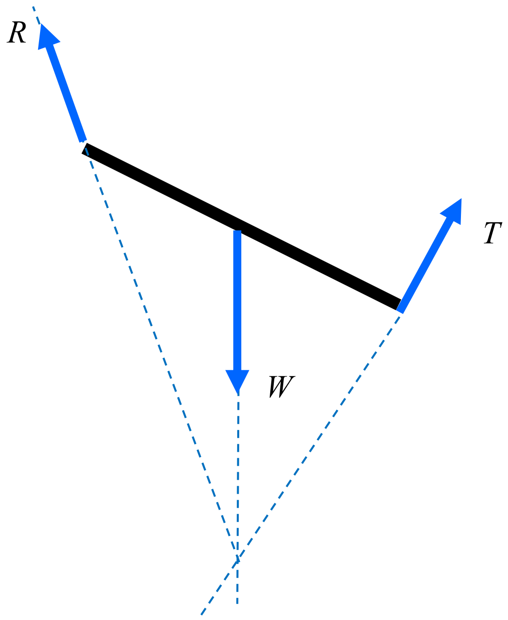
For A,
Force = d(mv)/dt
= 6(- 3.33 - (-5))/ (2.0 x 10^{-3})
= 24999
= 25 000 N

Examiner's Comments:

- Many students only got 1 mark as they did not see that the time at the x-axis is in milliseconds.
- However, apart from that, most students are able to get at least 1 mark.

(b)(i)	When water goes into or exit the ballast tanks, the weight of the submarine will change. If the weight is bigger than upthrust, the submarine will sink, if the weight is smaller than upthrust, it will float.	[1]
(ii)	$\Delta(mv) = m(\Delta v)$ = area under the graph $500\ (\Delta v) = 0.5\ (500 \times 10^{-3})\ (30000)$ $\Delta v = v_f - v_i = 15$ $v_f = 15 + 2 = 17$ m s^{-1} **Examiner's Comments:** • A significant number of students forgot that the area of the graph gives change in velocity, not final velocity and forgot to add that to the initial velocity for the final velocity.	[1] [1]

Prelim

3 (a)	Resultant/ net force is zero Resultant/ net moment about any axis/point is zero	[1] [1]
(b)(i)	 • T and W correctly labelled with full name, T and W in correct direction. • All 3 forces intersect to meet at a common point (clearly shown with dotted lines!) and R correctly labelled & in correct direction *W* is the weight of the rod, *T* is the tension acting on the rod, *R* is the force acting on the rod by the hinge/ contact force {do not accept: "normal contact force"}.	[1] [1]
(b)(ii)	Take moments about the hinge, $30 \times 9.81 \times \cos 30°(\frac{L}{2}) = T \times L$ (LHS & RHS each 1m) $T = 127.4 \approx 127\,N$ {penalise 1m for scale diagram methods}	[1,1]

(b)(iii)	$(\leftarrow +)\quad R_X = T\sin 30^o = 127.4\sin 30^o = 63.7\,N$ $(\uparrow +)\quad R_Y = 30\times 9.81 - T\cos 30^o = 184\,N$ $R = \sqrt{R_X^2 + R_Y^2} = \sqrt{63.7^2 + 184^2} = 194.7 \approx 195\,N$ ecf allow $\tan\theta = \frac{184}{63.7} \Rightarrow \quad \theta = 70.9^o$ above the horizontal as shown in Fig. 1 ecf allow {accept cosine rule method, 3m, with correct R direction} {award ecf 2m only for cases with wrong R in 'opp direction'}	[1] [1] [1] [1]

2019 FE

4(a)	Gravitational potential at a point is the work done per unit mass (by an external agent) in bringing a small test mass from infinity to that point (without any change in kinetic energy).	[1] [1]
(b)(i)	Potential at infinity is assigned value of zero. Since the gravitational force is attractive, work done to bring the test mass from infinity to a point near the surface is negative. (force and displacement are in opposite direction) {Unacceptable: giving work a direction and stating it is in the opposite direction as displacement}	[1] [1]
(ii)	g = - dϕ/dr $g = -\frac{-4.0x10^5 - (-5.0x10^5)}{0.6x10^3}$ (these are the lines that are closest to the surface thus the most reasonable choice), = -167 N kg^{-1} {Unacceptable: assume the same g on asteroid's surface and the potential line on top and form two equations using g = Φ/R and solve stimultaneous equations. Answers must be estimated from g = - dϕ/dr as it is an estimation question}	[1] [1] [1]
(iii)	Using surface and first line, $-5.0\times10^5 = -\frac{GM}{R}$ $-4.0\times10^5 = -\frac{GM}{R+600}$ Solving, R = 2400 m Sub R into either eqn, M = 1.8 x 10^{19} kg {Students can use any pair of potential lines to solve; small differences in answers are accepted. Students not allowed to use the g calculated in (ii) as one of the 2 equations as it is an estimate}	[1] [1] [1] [1]

(iv)	$\frac{1}{2}mv^2 + (-\frac{GMm}{R}) = 0$ $v = \sqrt{\frac{2GM}{R}}$ v = 1000 m s^{-1} {Students do not need answer to (iii) to do this part. They can just use potential on Earth's surface to find escape speed but 'error carried over' is given for students who use (iii) answers which were actually wrong}	[1] [1]

2018 FE

5 **(a)** Simple harmonic motion is an oscillatory motion in which the acceleration is proportional to its displacement from the equilibrium position [1]
and is always directed towards that point. [1]

Alternatively,

Simple harmonic motion is an oscillatory motion in which the acceleration is proportional to, [1]
and opposite in direction to the displacement from the equilibrium position. [1]

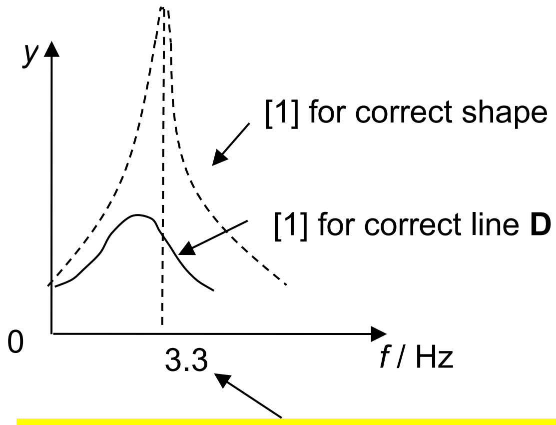
[Common error : It is not ideal to state that acceleration is proportional to negative displacement. Some students also mistakenly thought that the '-ve' in "a α –x" means inversely proportional.

For such definition, it is desirable to start the sentence appropriately, such as stating "it is an oscillatory motion where" instead of starting the sentence with "it is when acceleration is proportional….**]**

(b) **(i)** **1.** amplitude = $\frac{7-4}{2}$ = 1.5 cm [1]

2. f = $\frac{1}{T}$ = $\frac{1}{0.3}$ = 3.3 Hz [1]

(ii) 1. & 2.



Errata: Since Fig 5.2 show an exponentially decreasing amplitude as the metal tube is oscillating in "water" which will result in damping. The peak for 1. should be sharp but not go to infinity. 2. with increased damping should have lower and broader peak that shift more to the left than the graph in 1.

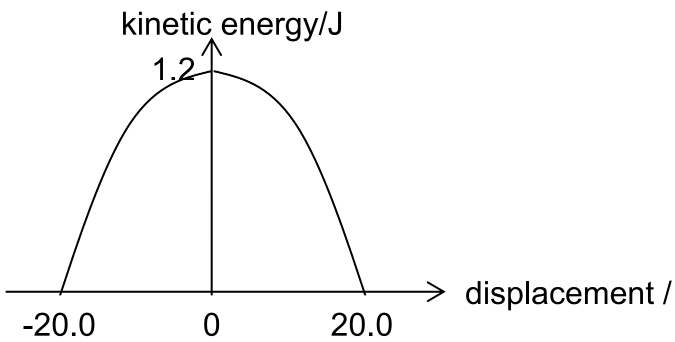
Graph **D** must have **3 features**:

1. peak shifts to left 2. peak is less sharp 3. amplitude < 1st Graph.**}**

[Common error: It is incorrect to start the graph at the origin as it would mean the amplitude is zero at that point.**]**

(c) (i) $\omega^2 = \frac{k}{m}$ => $\omega^2 = \frac{60}{5} = 12.$

$KE_{max} = ½mx_o^2\omega^2 = ½(5)(0.2)^2(12) = 1.2$ J [1]



Correct shape [1]

All values correctly labelled **[**Units must be labelled**]** [1]

(ii) For vertical oscillations, TE = PE_{max} (either highest or lowest pt)

At equilibrium, mg = ke_o { e_o : equilibrium extension}
=> 5(9.81) = 60e_o
e_o = 0.8175 m [1]

Hence, at highest point, displacement x = 0.8175 – 0.20
= 0.6175 m [1]

TE = EPE + GPE (at highest point)
= ½kx^2 + 0
= ½(60)$(0.6175)^2$
= 11.4 J [1]

OR

at lowest point, x = 0.8175 + 0.20 = 1.0175 m [1]

TE = EPE + GPE
= ½kx^2 + mgh
= ½(60)$(1.0175)^2$ + (5)(9.81)(-0.40)
= 11.4 J
[1]

[Common error: Very few students realised that there is extension of the spring at the equilibrium position and that extension e_o should first be calculated.**]**

End of Mark Scheme