Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

January 2023

Pearson Edexcel International
Advanced Subsidiary Level in Physics
(WPH11) Paper 01: Mechanics and Materials

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General Remarks

This paper was concerned with the physics of forces, including gravitational forces, tension, reaction, and forces in fluids due to drag and upthrust as well as the effects of forces on the motion of objects in one and two dimensions. The effects of forces on the shape and structure of the materials of which the objects are made was also examined, and students were expected to apply abstract principles of mechanics to contexts they should have studied as well as new or more unfamiliar contexts.

On the whole, students had been well prepared for this exam and showed good ability in the more basic applications and simple recall questions such as the projectiles question **Q11**, the Hooke's law question **Q15(b)** and the viscosity question **Q12**. Candidates were able to deploy a good range of different strategies to solve problems where there were a variety of possible approaches, such as in the material selection question **Q14(b)(ii)** and the High Striker question **Q17(b)**.

Explanations of physical phenomena were less well attempted, perhaps not so well as in previous series. This was particularly evident in the trampoline question **Q15(c)** where students did not clearly show how the force involved were changing and how this affected the direction and magnitude of the resultant force. In **Q13(b)(ii)**, **Q16(b)(ii)**, **Q17(a),** and Q**17(c)** students often missed the point of how the physics affected the situations, though there were many good attempts. Students should be encouraged not to rush into answering questions without first reading them thoroughly.

In questions where a conclusion needed to be drawn or explained students were on the whole showing a comparison of a calculated result with the condition that it needed to satisfy, though some were losing the final mark by neglecting this. This applied to **Q14(b)(ii)** and **Q17(b)**.

Final answers must be correctly rounded, not truncated, and the use of truncated or rounded values in multi-stage calculations will not generally yield the required value for the final mark. It is advisable that students should use calculators to retain all significant figures for values carried forward and only round answers for the final line.

It was very pleasing to see a good standard of English in most papers.

SECTION A

Multi-Choice Items

	Subject	Correct response	Comment
1	Vectors and scalars	**C**	Power is a scalar quantity.
2	Gravitational field strength	**A**	Gravitational field strength is weight per unit mass.
3	Conservation of energy	**N/A**	This multiple-choice item was found to contain an error and has been removed from this report.
4	Determination of *g* by free fall	**D**	Air resistance and upthrust must be negligible for free-fall.
5	Uniform acceleration	**C**	Uniform a is given by $a = (v^2 - u^2) / 2as$
6	Vector addition by scale drawing	**B**	Vectors are placed "nose-to-tail" to find the resultant.
7	Interpretation of kinematics graph	**B**	Negative acceleration gives a decreasing gradient of a displacement-time graph.
8	Power	**B**	Time taken is work done divided by power
9	Determination of Young modulus	**B**	Diameter is required to calculate stress and original length is required to calculate strain.
10	Newton's third law	**B**	The forces are of the same type and act on different bodies.

Multi-choice items were generally very well-answered, students who scored well in Section A did not necessarily always go on to score a good mark overall.

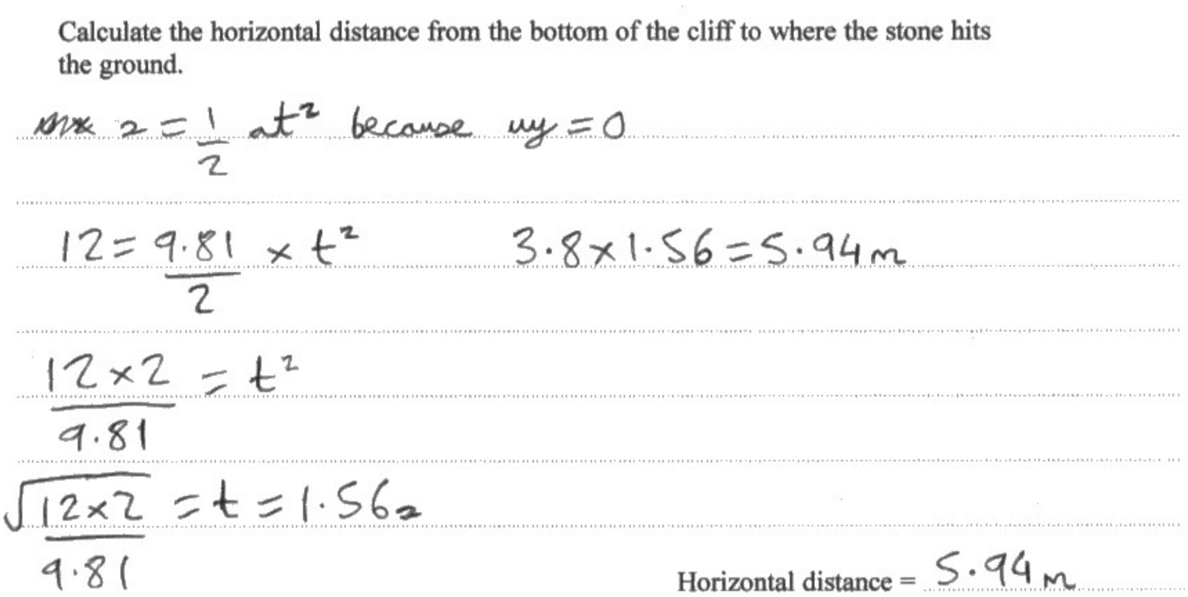
SECTION B

Examplar items show answers which scored full marks unless otherwise stated.

Question 11 The Stone and the Cliff

This very simple question required the candidate to calculate the time taken to reach the ground and then multiply that time by the the stone's (horizontal) speed, the vertical speed being initially zero.

Candidates generally coped very well with the question, the most common problem being in calculating the time to fall. A number of candidates got the fall time in two steps, which is fine, but wastes time and introduces a greater chance of errors. Others used $a = g$ in the horizontal plane, or $u = 3.8$ m s^{-1} in the vertical plane. Teaching students to set calculations out in two columns would help then to keep horizontal and vertical components clearly separated.



Calculate the horizontal distance from the bottom of the cliff to where the stone hits the ground.

$s = \frac{1}{2} at^2$ because $u_y = 0$

$12 = \frac{9.81}{2} \times t^2$ $3.8 \times 1.56 = 5.94$ m

$\frac{12 \times 2}{9.81} = t^2$

$\sqrt{\frac{12 \times 2}{9.81}} = t = 1.56$ s

Horizontal distance = 5.94 m

Question 12 The Falling Ball Experiment

This question tested candidates' knowledge of the theory behind the required practical in which the viscosity of a fluid is measured using a ball bearing falling through a fluid.

12a

Candidates are expected to know the quantities that can be measured using a balance and digital calipers, and for the most part the correct dimensions were identified and then used to determine the quantities required for the given equation. The most common mark not awarded was for the explanation linking the weight of fluid displaced with the upthrust.

It should be emphasised to students that calipers cannot directly measure the radius of a sphere; this was a common misconception. Some candidates thought that it would be useful to calculate the density of the sphere in order to get its weight, having already measured its mass.

12 A student determined the viscosity of a liquid using the falling-ball method.

(a) When the ball is falling at terminal velocity the following equation applies

drag force = weight of ball – upthrust

The density of the liquid was known. $\rho v g$

The student used a balance and a digital calliper to make measurements on the ball.

Describe how the student could use her measurements to calculate a value for the drag force acting on the ball.

(4)

The student must measure the mass of the ball and use $w=mg$ to find it's weight. upthrust = weight of liquid displaced, so we the equation $\rho_L V g$ to find upthrust. the volume of the sphere must be measured using $4/3\pi r^3$ after finding the diameter of the ball and ~~that~~ deviding it by 2 to find the radius. Then using $F = W - U$, subtrate the value of weight and upthrust to find drag force.

12b

This was a straightforward subsitution/rearrangement question which most candidates were able to accomplish without difficulty (though some struggled with the rearrangement). Very many students were unfamiliar with the unit for viscosity. Those who struggled to construct something using base units were given credit if they got it right, but many didn’t. Generally it is expected that candidates should know the correct unit for a quantity and allowing a mark for a construction in base units was an exceptional concession in this case.

Calculate the viscosity of the liquid.

terminal velocity of ball = $5.4 \times 10^{-4}\,\mathrm{m\,s^{-1}}$
radius of ball = $0.50 \times 10^{-2}\,\mathrm{m}$
drag force = $1.1 \times 10^{-2}\,\mathrm{N}$

(2)

$$6\pi r \eta v = F \Rightarrow \eta = \frac{F}{6\pi r v} = \frac{1.1\times10^{-2}}{6\times\pi\times0.5\times10^{-2}\times5.4\times10^{-4}}$$

$$= 216 \text{ Pa s}$$

Viscosity of liquid = 216 Pa s

Question 13 The Builder and the Stone

This was the turning moments question in which candidates could demonstrate their knowledge of the conditions required for rotational equilibrium.

13ai

Complete equilibrium requires two conditions thus two marks, and this simple question caused a surprising amount of confusion for many candidates. Centres should emphasise that simple clear conditions are worth learning, as these are easy marks to score for candidates who have taken the trouble to revise material thoroughly.

Those who simply said that forces were "balanced" needed to say more, as saying that forces are balanced is not adding anything to the statement that the object is in equilibrium.

(a) (i) State what is meant by equilibrium.

(2)

Equilibrium requires resultant force is zero along any direction and resultant moment is zero about any pivot

13aii

It is not true to say that the weight acts at the centre of gravity, candidates needed to imply that the centre of gravity is a calculation shortcut or that it represents some kind of average in order to score the mark.

The most common error was the contention that the weight acts at the centre of gravity, and occasionally that all the mass is concentrated there.

(ii) State what is meant by the centre of gravity of an object.

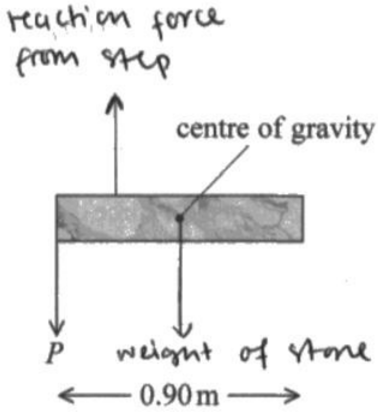
(1)

• place where weight is taken to act

13bi

Most had the weight drawn from the centre of gravity. There was a lot of leniency in the position of the reaction force but even so very many candidates had this force in completely the wrong position.

Students should be encouraged to use their imagination to visualise what might happen if the force *P* were removed to see where the reaction might act.



Complete the diagram above by adding labelled arrows to show the positions and directions of the other forces acting on the stone.

13bii

This question included the challenge to determine the positions of the forces from the geometry of the figure, and many candidates struggled with this. It was common to score the mark for knowledge of how to calculate a turning moment, and that was in many cases the only mark scored.

Students should be encouraged to annotate figures so that distances between the points of action of forces are clearly seen.

Calculate the magnitude of *P*.

(3)

Taking moments about edge,

Total clockwise moment = Total anticlockwise moment

$0.05 \times 415 = 0.4 \times P$

$P = \frac{0.05 \times 415}{0.4}$

$P = 51.875$ N

$P = 51.9$ N

Magnitude of *P* = 51.9 N

Question 14 The Machine Part

A design engineering question to give candidates the opportunity to demonstrate their knowledge of engineering materials and skill in material selection.

14a

Elastic deformation has a very clear definition and many candidates gave text-book answers to this question, showing that they had taken the trouble to memorise important aspects of the specification.

Others left out important details, such as that the force or stress must be removed in order for the material to return to its previous dimensions. A significant number of candidates answered the wrong question, giving definitions of elastic limit or describing Hooke's law, for example.

Students should be encouraged to learn definitions and to read questions slowly and carefully.

(a) State what is meant by elastic deformation.

(1)

When the Shape of an object changes but returns back to its original position when the stress is removed.

14bi

The drawn line on the graph very clearly has a gradient of 2.1, so there was not much latitude in awarding marks. Very many students used less than half the drawn line in determining the gradient, so did not score the first mark, and if points not on the line had been used it was very unlikely that the second mark would have been awarded. When a line goes through the origin, as this one does, the origin can be used as a point on the line.

It is not difficult to use more than half the drawn line, students should be encouraged to use as much of the drawn line as possible, there is then very little chance of a close call.

An answer to a "show that" question should always be given to at least one more significant figure than the value asked for. This should be emphasised to students.

(i) Show that the Young modulus for this metal is about 2×10^{11} Pa.

(2)

the gradient of the graph is Young modulus.

$$\frac{4.2 \times 10^{8} - 0}{2 \times 10^{-3} - 0} = 2.1 \times 10^{11} \text{ Pa.} \approx 2 \times 10^{11} \text{ Pa.}$$

14bii

There were many ways to answer this question, the most popular being the first suggested in the mark scheme, finding the actual extension of the rod when made of the suggested material and comparing that with the design specification. Finding the required Young modulus and comparing it with the actual was also popular, and some others were seen, all gaining due credit.

Nearly all candidates scored the mark for calculating the stress, but many struggled to combine the Young modulus formula with the strain equation for the second mark. The graphical method was not often seen.

To score the final mark we must see a clear comparison of two values, either in symbols or words, in order to justify a conclusion. Too many candidates simply stopped with a value for the extension or Young modulus and just left the examiner to draw the conclusion.

Deduce whether this metal is suitable for the part.

length of part = 0.84 m
cross-sectional area of part = $4.8 \times 10^{-3}\,m^2$

(4)

$\sigma = \frac{F}{A} = \frac{9.5 \times 10^5}{4.8 \times 10^{-3}} = 1.979 \times 10^8$ Pa $\simeq 2.0 \times 10^8$

Strain when stress of 1.979×10^8 Pa is applied

$= 0.95$

$\varepsilon = \frac{\Delta x}{x}$

$\Delta x = \varepsilon \times x$

$= 0.95 \times 0.84 \times 10^{-3}$

$= 0.798 \times 10^{-4}$

$\therefore$ ~~798~~ 0.798 mm > 0.6 mm

This metal is not suitable

Question 15 The Trampolinist

This question was principally about the application of Newton's second law, but also incorporated some elements of Hooke's law so that candidates could demonstrate ability to apply knowledge of elasticity to a mechanics problem.

15a

Candidates needed to identify the two forces acting on the gymnast and construct the correct equation for their resultant. This question was generally well answered, though many candidates subtracted the weight from the resultant force instead of adding it to find the upward force, scoring only two of the four available marks.

Calculate the maximum upward force of the trampoline on the gymnast.

mass of gymnast = 58 kg

(4)

The upward force only exist at the moment when gymnast was in contact with trampoline.

∴ Resultant force = R − W > 0

This is the moment that the "a" is at its maximum.

$R - W = ma$

$R = ma + mg$

$= 58 \times 14.2 + 58 \times 9.81 = 1392.58\,N = 1393\,N$

Maximum upward force = 1393 N

15bi

This was a simple trigonometrical procedure that nearly all candidates had little difficulty with. Those who did not score the marks generally had trouble re-arrangning the equation.

(i) Show that the tension in the spring is about 300 N.

(2)

$\sin(14) = \frac{68}{T}$

$T = 281\,N$

$\approx 300\,N$

15bii

This was another simple substitution/rearrangement question where most candidates had little trouble. Marks not awarded were generally for omitting correct units.

(ii) The extension of the spring was 4.6×10^{-2} m.

Calculate the stiffness of the spring.

(2)

k = stiffness $= \frac{F}{\Delta x} = \frac{281}{4.6 \times 10^{-2}} = 6108.69...$

$= 6110 \text{ N m}^{-1}$

Stiffness = 6110 N m^{-1}

15c*

This linkage question was not well answered and very few candidates scored full marks. Most were able to identify the first two indicitave points, though many failed to tell us the directions of the forces. Other indicative points were only rarely seen.

There was a marked tendency, in common with previous series, to answer in terms of energy transformations as if this were a GCSE question. The question clearly asks students to answer in terms of forces, and this should be the cue to talk about the relationship between the forces acting and how this affects the resultant force at any given time in the process.

It was also clearly stated in the question that the narrative should only concern the time during which the gymnast is in contact with the trampoline surface. Candidates should slow down and read the question very carefully in order to appreciate what exactly is being asked.

The following example scored five marks; five distinct indicative points were identified, scoring three marks, with two marks being awarded for clear reasoning.

IC1 line 2-3,IC2 line 3, IC4b line 4, IC6b line 4-6, IC3a line 6-7, IC4a line 8-9

Your answer should identify the forces acting on the gymnast and the directions of the forces. Ignore air resistance.

(6)

There are two forces acting on the gymnast, one is weight
the other is contact force acted by the trampoline. The weight is
downwards and keep constant. The contact force is upwards but varies
with time. At the lowest point, contact force is maximum and
greater than the weight. Resultant force is upwards, acceleration is
maximum and upwards. With the upward motion of the gymnast
the contact force decrease, the upward resultant force decrease,
the upward ~~resultant force~~ acceleration decrease. When the gymnast
loses contact with the trampoline. Contact force is zero, there is
only weight, so the acceleration is acceleration due to
gravity and downwards.

Question 16 The Spaceship

This question, based on real data for an actual spaceship, gave an opportunity for candidates to demonstrate their grasp of momentum and momentum conservation as well as the application of Newton's laws in the physics of rockets.

16a

The idea of initial momentum being zero seemed to be a new concept to many candidates, but there were many good answers to this problem. The final momentums of two modules were easily calculated, leaving the excess momentum for the descent module. The sign on the momentum and hence final velocity gives the direction of motion, and candidates needed to show that they understood the significance of the minus sign.

It would help candidates to mark clearly on the diagram which direction they are taking as positive.

Most student scored the first mark for calculating a momentum, but too many struggled to construct an equation to show momentum conservation.

momentum before = momentum after

$0 = (1350 \times -0.82) + (2950 \times v) + (2100 \times 0.58)$

$0 = -1107 + 2950v + 1218$

$0 = 2950v + 111$

$2950v = -111$, $v = -0.037$

Magnitude of v = 0.037 m s^{-1} Direction of v = to the left

16bi

This was a question that specifically asked for Newton's laws to be named, so without mention of the names of the laws only one mark could be scored at best. Candidates must read questions carefully. The third mark was often missed because candidates did not emphasise that the force of the gases on the rocket was the only force and therefore equal to the resultant force.

As the rocket motor ejects gases at high velocity, the rocket exerts a force on the gases backward. According to Newton's third law, the gases exert an equal force on the rocket forward. There is an unbalanced force acting on the rocket in the direction of its motion, so the rocket accelerates according to Newton's second ~~law~~ law.

16bii

This very simple question caused a surprising amount of trouble, particularly for candidates who did not read the question and took the change in velocity to be the final velocity, and then attempted to subtract their answer to part (a). Again, students should be encouraged to slow down and read the questions carefully.

(3)

$a = \frac{0.58}{5} = 0.116 \ ms^{-2}$

$F = ma$

$= 2950 \times 0.116 = 342.2$ (N)

Average force = 342.2 N

Question 17 The High Striker

This question was about conservation of energy and allowed candidates to show us how they can determine outcomes by using concepts of work, kinetic energy, gravitational potential energy and efficiency.

17a

The energy given to the hammer as it fell consisted of the work done by gravity and the work done by the person, thus greater than just the drop in g.p.e.. The question was not well answered, many failed to mention that the person had any influence on the fall of the hammer, and the word "work" was not often seen, though central to the explanation. The final mark was dependent on at least one of those two aspects being mentioned, and was often not awarded for that reason.

Because as the hammer is being swinged by a person when the hammer hit the bottom the froce applied by the penon on the hammer is also converted into KE so the KE on the hammer is greater as (work done + GPE is turned into KE)

17b

As with Question 14(b)(ii) there were a great many different ways to attack this question, the most popular being determining the actual height reached by the cylinder and comparing it with the height required. Other popular methods were to determine the actual and required input or output energies and compare them, also seen were required force and required efficiency.

The question was answered well on the whole but there some significant misconceptions by some candidates, for example that the hammer was in free fall, or that the mass of the hammer was 0.15 kg. Students should be reminded that a comparison between actual and required values is necessary to score the final conclusion mark. It was often very difficult, due to very rough and scrappy working, to understand what a candidate was trying to do with a calculation.

Deduce whether the cylinder hits the bell.

mass of cylinder = 0.15 kg
efficiency of energy transfer = 4.0%

(5)

Work done by the person = Fs
= 58 × 1.2
= 69.6 J

Energy gained by the cylinder = 69.6 J × 4.0%
= 2.784 J

Energy required to hit the bell = mgh
= 0.15 × 9.81 × 2.7
= 3.97305 J > 2.784 J

Therefore, the cylinder cannot hit the bell.

17c

This question was about the conversion of k.e. into g.p.e. and was not well answered, many candidates becoming distracted by considerations of air resistance and friction. The first marking point was most often seen.

(c) If the velocity of the hammer head as it hits the button doubles, the height gained by the cylinder does **not** double.

Explain why.

(2)

$E = \frac{1}{2}mv^2 = mgh$

As the velocity doubles, energy becomes the four times. so height gained by cylinder is 4 times, not double.

Question 18 The Lift Bag

The lift bag question was about bouyancy and terminal velocity with some aspects of Stokes' law required.

18ai

This question on the application of Newton's second law to buoyancy and drag was done much more successfully than Question 15(a), with many candidates scoring full marks. Those who did not score full marks would benefit from drawing a free body force diagram to help get the directions of the forces correct.

$W = mg \quad \rho = \frac{m}{V} \qquad W = mg = 35 \times 9.81$

$= 343.35\text{ N}$

$U = \rho V g$

$= 1.6 \times 10^{-2} \times 1.03 \times 10^{3} \times 9.81$

$= 161.6688\text{N}$

$D = W - U$

$= 343.35 - 161.6688$

$= 181.6812\text{ N}$

$= 180\text{ N (2 s.f)}$

18aii

A very simple substitution into a formula given in the question. Most candidates had little trouble with this, those that did stuggled with rearrangement. More practice would be beneficial.

Determine the terminal velocity of the object.

$k = 2.2\text{N s}^2\text{m}^{-2}$

(2)

$181.68 = 2.2 \times v^2 \rightarrow \frac{181.68}{2.2} = v^2 = 82.6$

$\sqrt{82.6} = v$

$v = 9.09$

Terminal velocity = 9.09 ms^{-1}

18aiii

Most candidates could state the conditions that should be met for Stokes' law to apply, but candidates needed to explain why the conditions were not met in order to score the marks. Most were able to do this, but a few just stated the conditions without any link to the situation with the lift bag.

(iii) Give **two** reasons why Stokes' law could **not** be used to calculate the terminal velocity of the object.

(2) Q18aiii

The object is travelling at a high speed, therefore the flow of fluid around it is unlikely to be laminar. The object is fairly large ([illegible]) ~~its volume~~ is 1.~~6×10~~$^{-2}$m^3 and it may not be spherical so stokes law doesnt apply

(b) To lift the heavy object from the seabed, a diver used a 'lift bag'.

The diver used compressed air from a cylinder to fill the lift bag, as shown.

18b

The final question was a set-piece explanation of an object achieving terminal velocity which candidates should not have had trouble with. Most were able to give a coherent explanation scoring some marks, but many concentrated on explaining why the lift bag accelerated in the first place and lost focus on the main points. Many candidates failed to score the final mark by not explaining that a maximum velocity is reached because accelertion becomes zero.

Explain why the lift bag and object reached a maximum velocity.

(3)

As lift bag applies constant upward force and an object has constant weight, the only ~~force~~ changing is drag, which is proportional to the velocity of a system. As velocity increases due to non-zero resultant force ~~from~~ (U of lift bag $> W_{object}$), the drag increases. At some point F of lift bag becomes equal to the sum of drag and weight of the system, thus $F_{res} = 0 \Rightarrow a = 0 \Rightarrow v$ is constant

Concluding Remarks

- Many students showed high levels of skill and knowledge of physics in this paper and it was very pleasing to see some of the excellent examples of the efficient solutions some students presented, especially in the Young modulus question **Q14(b)(ii)** and the High Striker question **Q17(b).**
- More time spent in reading the details of questions would greatly improve performance, particularly in the trampoline question **Q15(c)** and the energy conservation and work question **Q17**.
- Practice in graph work would also have been of great benefit for the Young modulus question **Q14(b)(i)**.
- Students should be encouraged to annotate calculations more clearly to help both themselves and others to follow an argument or calculation, particularly in the final lines where a conclusion is to be drawn.
- The recommendations for improving student performance remain similar to those in previous series, namely:

    - Practice in applying principles in a wide variety of different contexts will help build confidence and initiative.
    - Encouraging students to spend time in close reading of questions, and in re-reading both question and their answer, will help students avoid ambiguities and contradictions.
    - Learning basic definitions, and especially taking care to define quantities used, will avoid students failing to gain credit for concepts that they do in fact understand.
    - Encouraging students to use calculators correctly, to round answers to three significant figures in the last line only but to carry all significant figures forward from line to line in their calculations. Judicious use of calculator memory can avoid rounding errors.
    - Reminding students that rather than leaving entire questions blank they can score marks with some simple statements without necessarily knowing how to finish a question.

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