Examiners' Report
June 2023

International Advanced Level Physics WPH11 01

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June 2023

Publications Code WPH11_01_2306_ER

Introduction

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 were 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 energy question **Q13**, the projectiles question **Q14** and the Stokes' law question **Q16**. 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 moments question **Q19(b)(ii)** and the yield stress question **Q20(b)(ii)**.

Explanations of physical phenomena were less well attempted. This was particularly evident in the buoy question **Q17(b)** where students did not clearly show how the force involved was changing and how this affected the direction and magnitude of the resultant force. In the strain energy question **Q20(c)** and the momentum question **Q15(a)** students missed important points 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 marks by neglecting to state units where required. This applied to **Q16(b)(ii)**, **Q19(b)(ii)** and **Q20(b)(iii)**.

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	**D**	Weight is a force and therefore a vector quantity.
2	Resolution of forces	**B**	Component of force in the direction of motion us 225 N × cos 40˚
3	Stress and strain	**C**	Lesser diameter gives greater stress and thus greater strain, greater length gives greater extension for given strain.
4	Strain energy	**B**	Strain energy is equal to area under force extension graph up to the given extension.
5	Newton's third law	**A**	Forces act on different objects if they form a Newton third law pair.
6	Acceleration in free fall	**B**	Distance fallen from rest is given by $s = 0.5\, g\, t^2$
7	Uniformly acceleration	**D**	Acceleration is given by $a = (v^2 - u^2) / 2s$
8	Energy conservation	**C**	Loss of height is 20 m × sin 23˚. Final k.e. from rest is equal to loss of g.p.e.
9	Viscosity	**B**	Drag is equal to weight at terminal velocity, weight is constant. Viscosity decreases as temperature of liquid increases.
10	Hooke's law	**D**	Each spring extends by 7.5 mm for the same force of 45 N

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.

Question 11

Question 11 The Martian Rock

Candidates were asked to compare a time of fall on Mars with a time on Earth.

Many candidates had no trouble with this question, but a significant number became confused by the substitution required, writing 0.38 instead of 0.38*g* or 9.81*g* instead of just *g*.

11 A rock falls from rest through a small distance s to the surface of Mars. The rock hits Mars with velocity v_M.

Another rock falls from rest through distance s to the surface of Earth and hits Earth with velocity v_E.

Calculate the ratio $\frac{v_M}{v_E}$.

acceleration due to gravity on Mars = 0.38g

$$v_M^2 = u_M^2 + 2g_M s$$

$$v_M = \sqrt{2g_M s} = \sqrt{2 \times 0.38g \times s}$$

$$v_E^2 = u_E^2 + 2gs$$

$$v_E = \sqrt{2gs}$$

$$\frac{v_M}{v_E} = \frac{\sqrt{2 \times 0.38g \times s}}{\sqrt{2gs}} = \sqrt{\frac{\cancel{2} \times 0.38\cancel{g} \times \cancel{s}}{\cancel{2} \times \cancel{g} \times \cancel{s}}} = \sqrt{\frac{0.38}{1}} = 0.616$$

$\frac{v_M}{v_E}$ = 0.616

ResultsPlus Examiner Comments

This is a correct answer gaining 3 marks.

ResultsPlus Examiner Tip

As with this answer clear working out as shown is good practice.

Question 12

Question 12 The Diver

(a)(i) Candidates were asked to explain how a displacement-time graph showed zero velocity.

(a) (i) State how the graph shows that the man's initial vertical velocity is zero.

(1)

the velocity of the graph is given by the gradient and the ~~it~~ gradient at t=0 is zero [horizontal line] so initial vert velocity = 0.

ResultsPlus
Examiner Comments

Common mistakes were to state that the displacement was zero or to state $v = s / t$ and $t = 0$, so therefore v must be zero. Stating that a line is "flat" is not enough to establish a zero gradient.

ResultsPlus
Examiner Tip

Take heed of the above comments so as not to lose marks.

(a)(ii) Candidates were asked to derive a velocity using data read from the graph.

(ii) Determine the vertical velocity of the man as he enters the water. **(2)**

$v = \frac{6.5-(-4)}{1.8-1} = 13.1\ ms^{-1}$

Vertical velocity = $13.1\ ms^{-1}$

ResultsPlus
Examiner Comments

Most candidates used a calculation using equations for uniform acceleration and mostly gave correct answers. Those who calculated the gradient of the tangent had less success as often the tangent was at an incorrect point, or the candidate used the point on a section which was not quite straight.

ResultsPlus
Examiner Tip

It is good to highlight words on your question paper.

Question 13

Question 13 The High Speed Train

(b) Candidates were asked to determine the work against air resistance by calculating the difference between the total work accelerating the train and the final kinetic energy.

(b) The train accelerates for 180 s. The train has an input power of 16 MW while accelerating.

Determine the work done against air resistance as the train accelerates.

(2)

Useful power $2.08 \times 10^9 / 180 = 11.55\,MW$

$(16 - 11.55) \times 10^6 \times 180 = 8.0 \times 10^8\,J$

Work done against air resistance = $8.0 \times 10^8\,J$

ResultsPlus
Examiner Comments

Many candidates misread this question and just calculated the work total work done, scoring just one mark. Candidates who attempted a ΣF = m approach scored no marks as, again, there is no indication that the forces were constant.

ResultsPlus
Examiner Tip

An excellent answer.

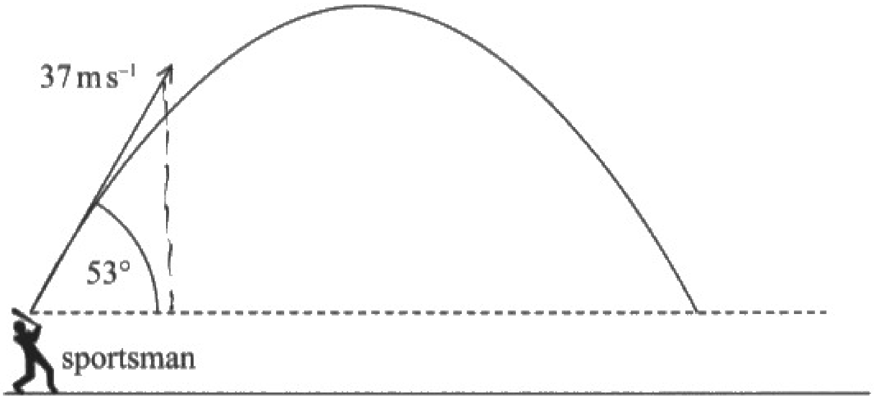
Question 14

Question 14 The Sportsman

Candidates were asked to find how far a ball hit by a batsman travelled before hitting and returning to its launch height.

14 A sportsman hits a ball with a bat.

The ball leaves the bat at a speed of $37\,\mathrm{m\,s^{-1}}$ at an angle of 53° to the horizontal, as shown.



Calculate the horizontal distance travelled by the ball before returning to the height it was hit from.

$U_V = 37\sin53° = 29.55\ ms^{-1}$. $U_H = 37\cos53° = 22.27\ ms^{-1}$.

$s = ut + \frac{1}{2}at^2$. in vertical direction

$0 = 29.55t + \frac{1}{2}\times(-9.81)\times t^2$

$t = 6.02$ or 0 (ignore up).

So $S_H = vt = 22.27 \times 6.02$

$= 134.1$ m.

Horizontal distance = 134.1 m.

ResultsPlus
Examiner Comments

It was very common for candidates to score only two marks for this question by calculating the time to maximum height (vertical velocity zero) and multiplying that time by the horizontal velocity to obtain half the range.

It was also common to see candidates doubling the time to maximum height and scoring all the marks, a less reliable method than setting final vertical displacement to zero and using s=u t + ½ a t2 with u=0 and a = − g.

There were many small slip-ups in calculations seen; candidates need to set out their working out much more clearly to help them follow their own working.

ResultsPlus
Examiner Tip

Clear working out.

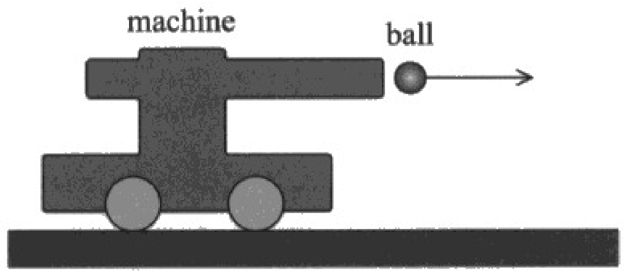
Question 15 (a)

Question 15 The Ball Launcher

(a) Candidates were asked to explain why the launcher recoils when a ball is launched.

15 The diagram shows a machine used to launch tennis balls in a horizontal direction.

The machine is on frictionless wheels.



Before a tennis ball is launched, the machine is stationary.

(a) Explain, in terms of momentum, why the machine starts to move as the ball is launched.

(3)

- initial momentum = 0 since velocity = 0
- as the ball is launched, it has a forward momentum.
- there's no external forces so total momentum is conserved.
- so the machine has a backward momentum with the same magnitude of the ball, and so the machine has a backward velocity.

ResultsPlus
Examiner Comments

Common errors included the usual absence of the word "sum" or "total" regarding the momentum of a system, rather than of an individual component. Many candidates gave a very good explanation in terms of Newton's laws but gained no credit as the question specifically asked for an explanation in terms of momentum. A good number of answers did not mention momentum at all.

ResultsPlus
Examiner Tip

Again, the important word was highlighted on the answer sheet.

Question 15 (b)

The Ball Launcher

(b) Candidates were asked to calculate the recoil velocity of the launcher.

(b) Calculate the velocity of the machine just after the ball is launched.

velocity of ball = $4.5\,m\,s^{-1}$
mass of ball = 0.056 kg
mass of machine = 2.9 kg

(3)

$P_f = P_i = 0$

$P_f = m_m v_m + m_b v_b = 0 \quad 2.9\,V_m + 0.056 \times 4.5 = 0$

$2.9\,V_m = 0.056\,(4.5)$

$\Rightarrow V_m = -0.087\,ms^{-1}$

Velocity of machine = $-0.087\,ms^{-1}$

ResultsPlus
Examiner Comments

This was generally well done, though there were many instances of power of ten and truncation errors due to careless working. Weaker answers confused momentum with kinetic energy and made errors by adding masses unnecessarily.

Question 16 (a)

Question 16 The Bubble

(a) Candidates were asked to give an additional condition for Stokes' law beyond those given in the question.

16 A small, spherical air bubble moves upwards in a glass of water. The drag force on the bubble can be calculated using Stokes' law.

(a) State the condition needed for Stokes' law to apply to the bubble.

(1)

Laminar flow

ResultsPlus
Examiner Comments

Most were able to score this mark. A description of the flow was required, so simply stating "laminar" was not sufficient. Candidates who prefer minimal wording (also preferred by examiners) must remember that there must be sufficient content to answer the question.

ResultsPlus
Examiner Tip

Concise.

Question 16 (b)

Question 16 The Bubble

(b)(i) Candidates were asked to calculate the upthrust on the bubble, so needed to know that they should calculate the weight of water displaced.

(b) The bubble moves upwards at a constant velocity.

The volume of the bubble is $5.3 \times 10^{-11}\,\text{m}^3$.

(i) Show that the upthrust on the bubble is about $5 \times 10^{-7}\,\text{N}$.

density of water = $998\,\text{kg}\,\text{m}^{-3}$

(2)

Upthrust = $\rho g V$ = $998 \times 9.81 \times 5.3 \times 10^{-11}$ = 5.189×10^{-7} N ≈ 5×10^{-7} N

ResultsPlus Examiner Comments

Most candidates had no trouble with this, though some candidates calculated just the mass.

(b)(ii) Candidates were asked to deduce whether Stokes' law applied in this particular case.

(ii) The bubble moves upwards at a constant velocity of $0.035\,\mathrm{m\,s^{-1}}$. v.

Deduce whether Stokes' law applies to the bubble.

You may ignore the weight of the bubble. $D = 6\pi r \eta v$.

viscosity of water $= 9.5 \times 10^{-4}\,\mathrm{Pa\,s}$ η.

(4)

$\frac{4}{3}\pi r^3 = 5.3\times10^{-11}$

$r = \sqrt[3]{\frac{3}{4}\times5.3\times10^{-11}\div\pi} = 2.33\times10^{-4}\,\mathrm{m}$

$D = 6\pi r\eta v = 6\pi\times2.33\times10^{-4}\times9.5\times10^{-4}\times0.035$

$= 1.46\times10^{-7}\,\mathrm{N}$

$< 5\times10^{-7}\,\mathrm{N}$.

$D < U$, so Stoke's law can apply to it

ResultsPlus
Examiner Comments

There were several valid methods, the most common approach being the one suggested by the mark scheme, to compare the drag predicted by the velocity of the bubble with the actual upthrust.

Finding the radius of the bubble proved challenging for many candidates, and it was common for candidates to miss one mark by neglecting units for their calculated values.

ResultsPlus
Examiner Tip

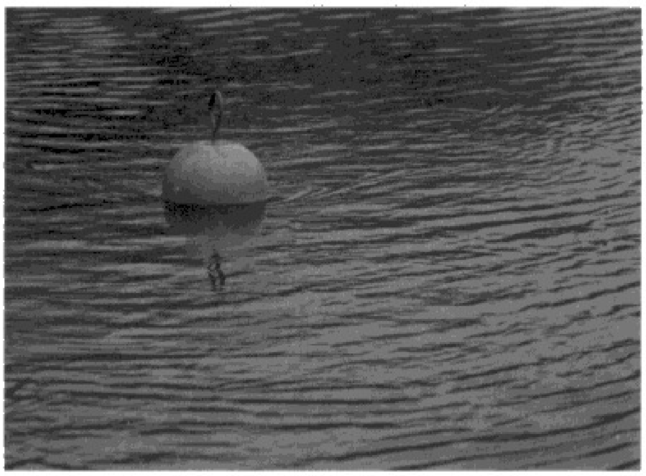
Candidates should be aware of the pitfalls of failing to distinguish between a V and a v.

Question 17 (a)

Question 17 The Buoy

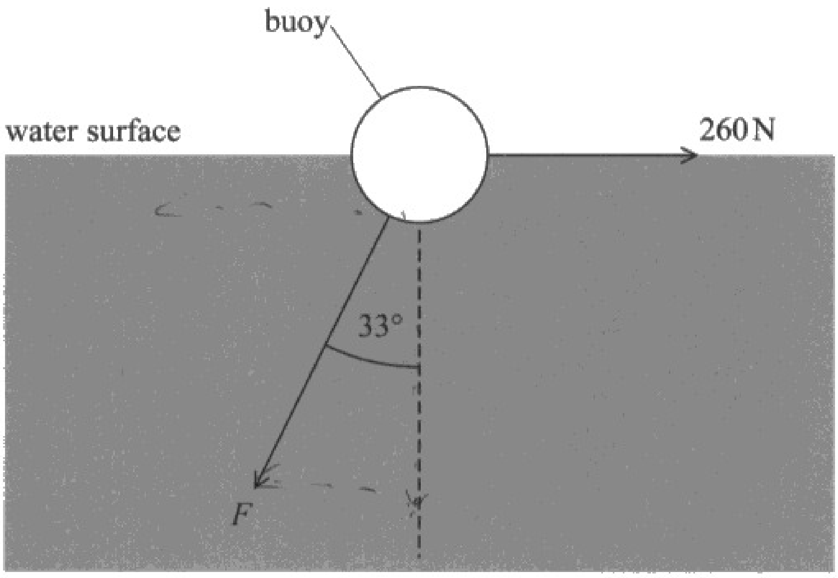
(a)(i) Candidates were asked to evaluate the tension in its mooring chain at the point where it connected to the buoy.

17 The photograph shows a floating object called a buoy. A long chain attaches the buoy to a very large mass at the bottom of the sea so that the buoy remains stationary.



(Source: © EThamPhoto/Alamy Stock Photo)

Water flowing past the buoy causes a horizontal force of 260 N on the buoy.
The chain exerts a force F on the buoy at an angle of 33° to the vertical as shown.



(a) (i) Show that F is about 500 N.

(2)

$F \times \sin 33 = 260$

$F = \frac{260}{\sin 33} = 477\ N$

ResultsPlus
Examiner Comments

Most candidates did not have difficulty with this question, which required the equating of the horizontal component with force from the current.

Occasional errors were generally with the trigonometry.

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Examiner Tip

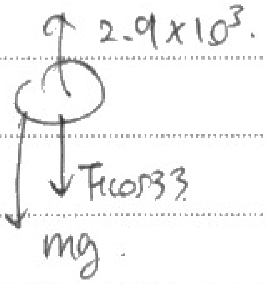
A correct answer.

(a)(ii) Candidates were asked to determine the weight of the buoy by calculating the difference between the upthrust and the vertical component of the tension in the mooring chain (as error from (a)(i) could be carried forward).

(ii) The buoy floats due to the upthrust from the water.
The weight of water displaced by the buoy is 2.9 kN.

Determine the weight of the buoy.

(3)



upthrust = weight of water displaced by buoy. = 2.9 kN.

$2900 = T\cos 33 + \text{weight}$

$W = 2900 - 477 \times \cos 33 = 2499.9$...

$\doteqdot 2.5$ kN.

Weight of buoy = 2.5 kN.

ResultsPlus
Examiner Comments

Common errors were adding the two forces, using the full value from (a)(i) or finding the mass instead of the weight.

ResultsPlus
Examiner Tip

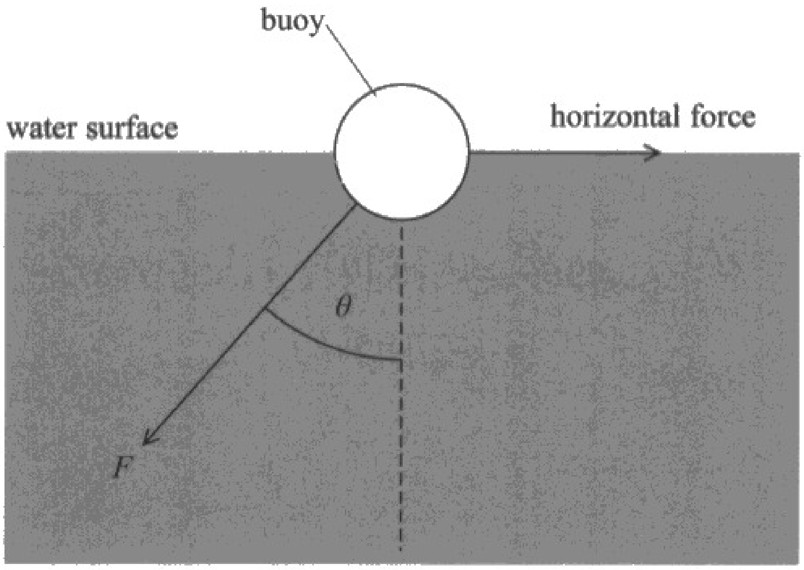
This was well thought through.

Question 17 (b)

Question 17 The Buoy

(b) Candidates were asked to explain how the tension and the angle of the mooring chain would change with an increase of horizontal force from the current.

(b) The speed of the water flowing past the buoy increases, so the horizontal force increases. Assume that the weight of water displaced by the buoy does not change.



Explain how F and θ change when the horizontal force increases.

(3)

① as the horizontal force increase, the horizontal component of F increase.

② the vertical componet of F equals to upthrust - weight, which is fixed

③ $\tan\theta = \frac{\text{horizonal comp.}}{\text{vertical comp.}}$, as horizonal comp. increase, $\tan\theta$ increase

④ so θ increases as $\theta \in (0, 90°)$

⑤ $F = \text{vertical comp.} \div \cos\theta$, vertical comp. is fixed, $\cos\theta$ is decrease due to increase of θ, so F increases

ResultsPlus Examiner Comments

Most candidates were able to infer that the horizontal component of the tension increased, but a statement about the vertical force was also required for the first marking point. Further marks were only rarely awarded as the full answer required some trigonometrical reasoning that only a few of the candidates were able to produce.

ResultsPlus Examiner Tip

Practice your trigonometry during revision time.

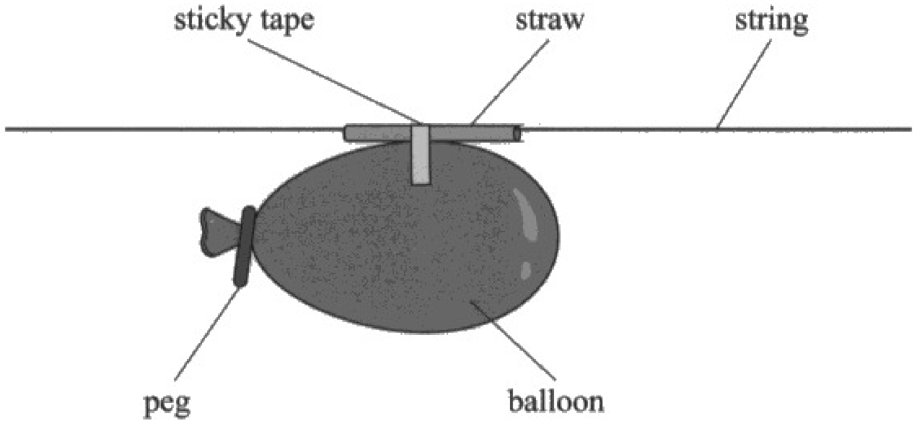
Question 18

Question 18 The Balloon Rocket

Candidates were asked to explain the motion of a balloon rocket from the moment the air was released to the instant when it achieved terminal velocity.

*18 A student inflates a balloon. She uses a peg to keep the balloon closed. She then attaches a straw to the balloon using sticky tape.

She passes a string through the straw and pulls the string tight, as shown.



The student removes the peg and air leaves the balloon.

The velocity of the balloon increases from zero to a maximum.

Explain how Newton's three laws of motion apply to the motion of the balloon during this time.

As the peg is removed balloon exerts an backward force on air and by N 3rd law air exerts an equal and forward force on balloon, hence by N 2nd law there is a forward resultant force hence there is acceleration, acting up on straw that causes it to move forward initially as peg is removed there is larger Forward force than air resistance hence resultant force acts forward accelerating, as velocity increases forward force is equal to air resistance hences by N 1st law since there is no resultant force there is no acceleration, hence balloon moves at steady speed as it deflates and than momentarily comes to rest.

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Examiner Comments

Candidates were generally able to score marks on this question, but very few were able to give a complete explanation.

Common errors included:

- Air in the balloon exerting a force on the air outside the balloon means the air outside the balloon exerts a force on the balloon.
- The elastic potential energy of the balloon is transferred as kinetic energy.
- Use of the term “pushes” instead of "exerts a force".
- References to before the peg is removed as an example of Newton’s first law.
- Quoting the three laws and nothing else.
- Referring to the balloon losing mass as the air is expelled, thus there is an increase in acceleration.
- The straw exerting a force on the string, the string exerting equal and opposite force on the straw.
- Stating that the balloon accelerated due to a resultant force without explaining where this force came from.

Very few candidates referred to the overcoming of resistive forces.

A few candidates attempted to use conservation of momentum to explain the motion of the balloon.

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Examiner Tip

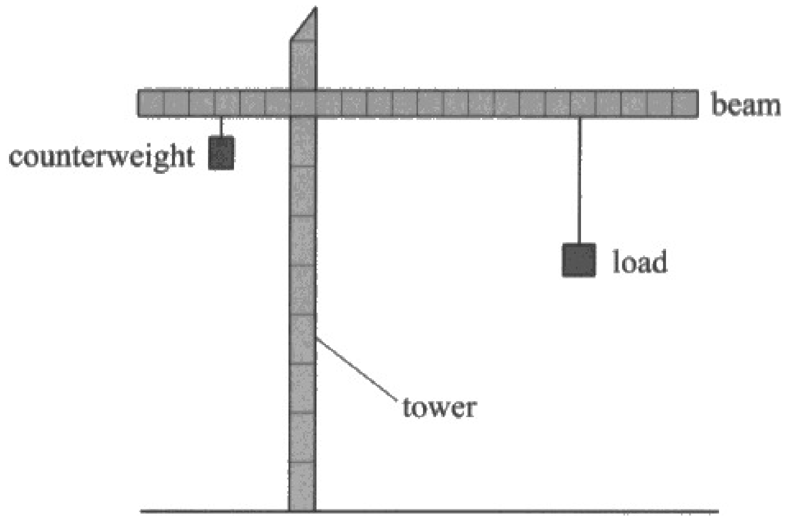
A clear and legible answer for full marks.

Question 19 (a)

Question 19 The Crane

(a) Candidates were asked to calculate the input power of a crane with a given efficiency.

19 The diagram shows a crane lifting a load. There is a large mass called a counterweight attached to the crane, on the opposite side of the tower to the load.



(a) The crane has an electric motor with an efficiency of 47%.

The crane lifts a load of 4.4×10^4 N. The load moves through a vertical distance of 15 m in a time of 70 seconds.

Determine the average power input to the electric motor.

(4)

(a) $P = \frac{W}{t}$

$= \frac{4.4 \times 10^4 N \times 15m}{70}$

$= 9428.57 \cancel{J} W$

~~9428.57 ÷ 48%~~

9428.57 ÷ 47% = 20060.79 W

Average power input = 20060.79 W

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Examiner Comments

Most candidates had little difficulty with calculating the output power, but many struggled with applying efficiency, common errors being multiplication by the efficiency, confusion with percentages and unit errors.

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Examiner Tip

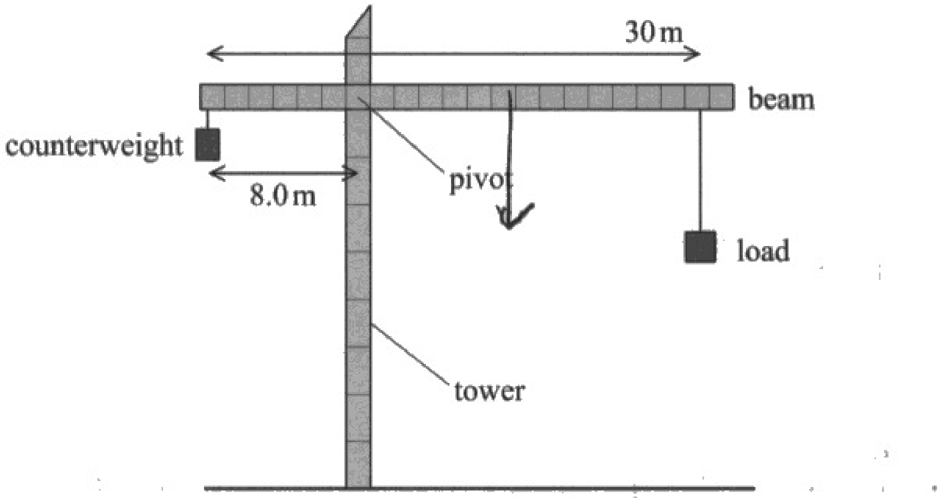
Underline key words as in this example.

Question 19 (b)(i)

Question 19 The Crane

(b)(i) Candidates were asked to explain how a counterweight is used to maintain the crane's equilibrium.

(b) The horizontal distance from the load to the tower can be changed. The horizontal distance from the counterweight to the tower can also be changed.



(i) Explain how the counterweight needs to move when the load is moved away from the tower.

(4)

- Sum of clockwise moment = Sum of anticlockwise moments
- counterweight provides anticlockwise moment, load and weight of beam provides clockwise moment
- Moment = Force x perpendicular distance from pivot
- As the load is move away from tower, distance from pivot increases, ~~anti~~clockwise moment increases.
- ∴ counter weight should be moved away from tower to increase anticlockwise moment.

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Examiner Comments

Full explanations were rare, particularly regarding the significance of the centre of mass of the beam. Most candidates knew that the counterweight should be moved outwards, though a large number thought it should be moved closer to the pivot. Candidates only rarely stated that the total moment should be zero.

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Examiner Tip

Bullet points are good.

Question 19 (b)(ii)

Question 19 The Crane

(b)(ii) Candidates were asked to deduce whether a given load could be moved to the end of the beam.

(ii) The beam is uniform with a weight of 3.0×10^4 N.
The counterweight has a weight of 1.1×10^5 N.
The load has a weight of 4.4×10^4 N.

Deduce whether the load can be moved to the end of the beam without the crane toppling.

(5)

$moment_1 = Fx = 3 \times 10^4 \times 7 = 2.1 \times 10^5$ Nm

$moment_2 = F_x = 4.4 \times 10^4 \times 22 = 9.68 \times 10^5$ Nm

$moment_3 = moment_1 + moment_2$

$Fx = 2.1 \times 10^5 + 9.68 \times 10^5$

$1.1 \times 10^5 x = 2.1 \times 10^5 + 9.68 \times 10^5$

$x = 11$ m

$11 > 8$

so the load can't be moved to the end of the beam.

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Examiner Comments

Candidates who annotated their diagrams tend to do better with moment problems than those who do not. It was very difficult to follow some candidates' working.

Most candidates chose to work out the respective moments with load and counterweight at their maximum distances from the pivot. Common errors included assuming that the load was 30 m from the pivot, using the incorrect distance when calculating the moment of the CoG (sometimes putting it on the wrong side) or the omitting of the CoG moment.

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Examiner Tip

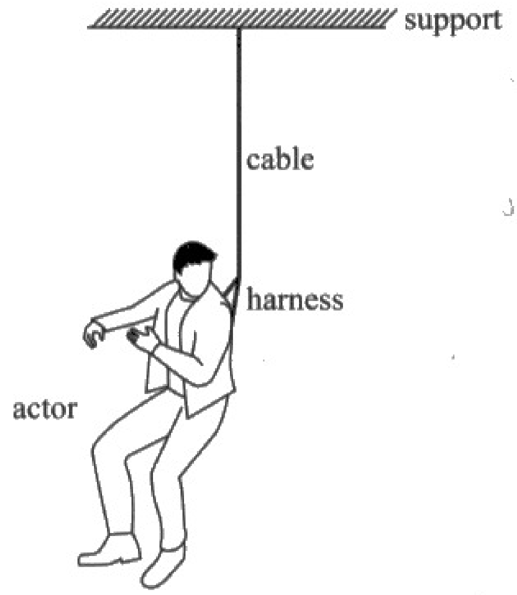
Make sure your answers are clear like this one.

Question 20 (a)

Question 20 The Stunt Harness

(a) Candidates were asked to give the standard definition of yield point.

20 An actor is wearing a harness. The harness is connected to a cable and support, as shown.



(a) The force on the cable must not cause the material of the cable to reach its yield point.

State what is meant by the yield point of a material.

(1)

A stress value beyond which the material undergoes a sudden and large ~~prast~~ plastic deformation

ResultsPlus
Examiner Comments

It seemed that very few candidates had learned this definition which needed to include two elements to score the mark, the idea of a large increase in strain and that the strain must be plastic.

Though a number of correct definitions were seen many candidates only gave an element of the definition and thus did not score this mark. A greater emphasis on learning such definitions would benefit candidates in this type of question.

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Examiner Tip

Learn definitions for this type of question.

Question 20 (b)(i)

Question 20 The Stunt Harness

(b)(i) Candidates were asked to explain why the forces acting on the actor could cause him to accelerate upwards.

(b) The cable and harness are used to accelerate the actor vertically off the ground.

(i) Explain why the forces acting on the actor cause him to accelerate upwards.

(2)

The tension in the cable is more than the weight of the actor, so there is a resultant force upwards. Therefore he ~~act~~ accelerates upwards.

ResultsPlus
Examiner Comments

Precise use of terms was required to score these marks, the nature of the forces needed to be clear, and candidates often fail to mention that it is a resultant force which causes acceleration.

This question was answered well as nearly all candidates scored at least one mark with many scoring full marks on this question. The most common error was to subtract the weight from the net force rather than adding it.

ResultsPlus
Examiner Tip

A good explanation.

Question 20 (b)(ii-iii)

Question 20 The Stunt Harness

(b)(iii) Candidates were asked to deduce whether it was safe to use the given cable to accelerate the actor at the given rate.

(iii) To make sure the actor is safe, the stress in the cable must be less than 15% of the yield point stress.

The cable has a yield point stress of 2.5×10^8 Pa.

The diameter of the cable is 7.6×10^{-3} m.

Deduce whether it is safe to lift the actor with an acceleration of $2.1\,\mathrm{m\,s^{-2}}$.

(4)

$$\sigma = \frac{920\,\mathrm{N}}{\pi(3.8\times10^{-3}\,\mathrm{m})^2} = \frac{920\,\mathrm{N}}{4.536\times10^{-5}\,\mathrm{m}^2} = 2.03\times10^{7}\,\mathrm{Pa}$$

Yield point $= 2.5\times10^{8}\,\mathrm{Pa} \times 0.15 = 3.75\times10^{7}\,\mathrm{Pa} > 2.03\times10^{7}\,\mathrm{Pa}$

$\therefore$ It is safe

ResultsPlus
Examiner Comments

Most candidates knew how to approach this question, with marks being lost mostly in confused attempts to work out the cross-sectional area of the cable or neglecting units. There were several different ways to tackle the question, most opting for comparing the actual stress with the allowed stress.

ResultsPlus
Examiner Tip

This is correctly deduced.

(b)(ii) Candidates were asked to determine the tension in the cable required to accelerate the actor upwards at a given rate.

(ii) The actor has a mass of 77 kg and is lifted vertically from the ground with an acceleration of $2.1\ \mathrm{m\,s^{-2}}$.

Show that the tension in the cable is about 920 N.

(3)

~~F = ma~~

$T - 77 \times 9.81 = 77 \times 2.1$

$T = (77 \times 2.1) + (77 \times 9.81)$

$T = 917.1$ N

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Examiner Comments

Most candidates knew how to approach this question with marks being lost mostly in confused attempts to work out the cross-sectional area of the cable or neglecting units. There were several different ways to tackle the question, most opting for comparing the actual stress with the allowed stress.

Question 20 (c)

Question 20 The Stunt Harness

(c) Candidates were asked to compare the work required to break the original cable with a cable of greater diameter made from a material with a lower Young modulus.

(c) The original cable is replaced with a new cable made from a different material. This material has a lower Young modulus than the material used to make the original cable.

$E = \frac{\sigma}{\varepsilon}$ $\sigma = \frac{F}{A}$

The new cable is the same length as the original cable but has a greater diameter.

$E = \frac{FL}{A e}$

The breaking stress is the same for both cables.

Explain how the work done to break the new cable is different from the work done to break the original cable. Assume that both materials obey Hooke's law up to the breaking point.

(4)

Stress $= \frac{\text{Force}}{\text{area}}$, since breaking stress is the same even though cable has a greater cross sectional area (due to greater diameter), the breaking force must increase. ($F \propto A$).

Young Modulus $= \frac{Fx}{A\Delta x}$, since young modulus is lower for the new material, and breaking stress is the same, the breaking strain must be higher ($E = \frac{\sigma}{\varepsilon}$). But the length of cable is the same so for strain to be higher ($\varepsilon = \frac{\Delta x}{x}$), the extension must be higher.

(Total for Question 20 = 14 marks)

Since work done $= \frac{1}{2} F \Delta x$ and both F and Δx are higher, work done to break new cable is greater.

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

ResultsPlus
Examiner Comments

Good answers to this question were only rarely seen. Most candidates did not realise that breaking stress was unchanged, and often stated that greater stress was required to break the new cable despite this being clearly contradicted by the question.

ResultsPlus
Examiner Tip

It is dangerous for candidates to write outside the given answer spaces as examiners may not see that work. Candidates should ask for extra paper if they run out of space.

Paper Summary

Concluding Remarks

- More time spent in reading the details of questions would greatly improve performance, particularly in the Stunt Harness question **Q20(c)** and the momentum question **Q15(a)**.
- Practice in interpreting graphs would also have been of great benefit for the Diver question **Q12(b)**.
- 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.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

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