OCR A-Level Physics: Practice Paper 2

Focus: Analysis & Practical Skills

Difficulty: Hard

Time: 2 hours 15 minutes

Marks:

Section A (multiple choice): 30 marks (40 minutes)

Section B (standard questions): 70 marks (1 hour 35 minutes)

(Total 100 marks)

Grade Boundaries: (approximate)

A*: 80 (80%)

A: 70 (70%)

B: 60 (60%)

C: 50 (50%)

D: 40 (40%)

Main Topics Examined:

Practical Skills, Foundations of Physics, Forces, Oscillations, Particle Physics, Thermal Physics, Electromagnetism, Capacitors

Advice:

1. Read the questions carefully - look out for tricks.
2. Some questions are harder than the A-level standard.
3. Apply existing knowledge to unfamiliar questions.
4. Check the fully worked solutions for any questions you missed.

Section A: Multiple choice. You are advised to spend no more than **40 minutes** in Section A.

1. A ripple tank was used to investigate the relationship between the speed of a surface water wave v and the depth of the tank d.

   It is thought that the relationship between the variables is of the form $v = k\,d^{\,n}$, where k and n are constants. When a graph of ln v on the y-axis against ln d on the x-axis was plotted, the line of best fit had a gradient of 0.5.

   The relationship between v and d, based on this data, is of the form

   O $v = 2\,d^{\,k}$, where k has no units
   O $v = k\,d^{\,2}$, where k has units of $ms^{-1/2}$
   O $v = k \ln d$, where k has units of ms^{-1}
   O $v = k\sqrt{d}$, where k has units of $m^{1/2}s^{-1}$ [2 marks]

2. A mass m is attached to one end of a spring of force constant k and the other end is fixed at a position vertically above the mass. The mass is pulled down and then released at time $t = 0$. The mass performs simple harmonic motion in a vertical line. At any time t, the displacement of the mass **above** the equilibrium position is x and the time period of oscillation of the mass is T.

   Which, if any, of the following statements is/are true?

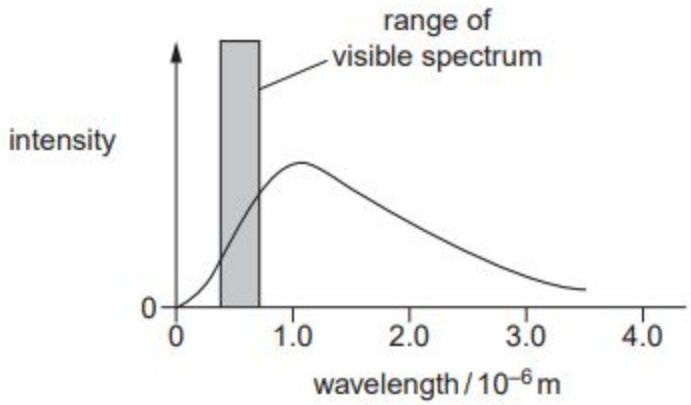
   1 The sum of the kinetic energy of the mass and the elastic potential energy stored in the spring at any time is constant.

   2 When $x = 0$, the spring is at its natural unstretched length and therefore exerts no thrust or tensile force.

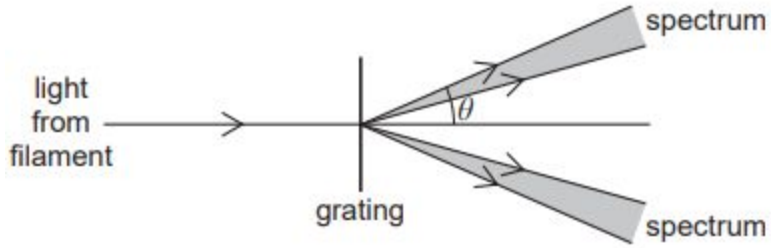
   3 The velocity of the mass is opposite and proportional to the displacement.

   O **1** and **2** only
   O **1** and **3** only
   O **2** and **3** only
   O None of them [2 marks]

3. The tungsten filament of a 12 V / 24 W lamp glows white hot emitting photons across a continuous spectrum of energies. The intensity variation with the wavelength of the electromagnetic radiation from the filament is shown below.



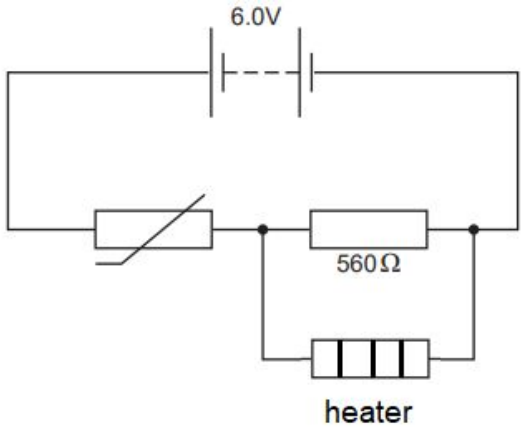
When the light from the filament is focussed through a diffraction grating having 300 lines per millimetre, the continuous first order visible spectrum is seen on a circular screen perpendicular to the light at angles of θ = 7° and 12°.



At angles of θ = 7° and 12°, the colours and relative intensities seen on the screen are, respectively,

O 7°: red (brightest), 12°: violet (dimmest)
O 7°: red (dimmest), 12°: violet (brightest)
O 7°: violet (brightest), 12°: red (dimmest)
O 7°: violet (dimmest), 12°: red (brightest) [2 marks]

4. Consider the circuit below.



Assuming that the heater is thermally insulated from the rest of the circuit, which of these correctly describes the behaviour of this circuit?

O When the temperature is high, the heater dissipates a larger amount of thermal power.

O **If** the p.d. source was AC, the thermal power dissipated by the heater would vary periodically in time.

O The thermal power dissipated by the heater is constant at all temperatures.

O None of the above [2 marks]

5. The diameter of the Sun is known to be $(1.39 \pm 0.04) \times 10^6$ km and its surface temperature is (5770 ± 9) K.

If the Stefan-Boltzmann constant is known to be 5.67×10^{-8} W m^{-2} K^{-4} correct to 3 significant figures, then the calculated luminosity of the Sun and its associated uncertainty is

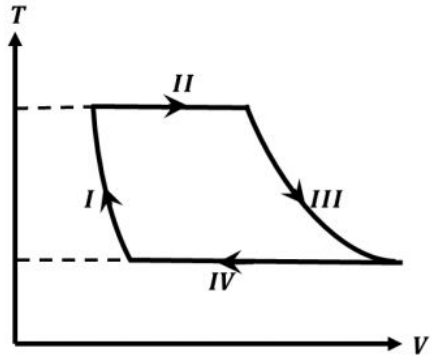
O $(3.81 \pm 0.24) \times 10^{26}$ W
O $(3.81 \pm 0.25) \times 10^{26}$ W
O $(1.53 \pm 0.09) \times 10^{27}$ W
O $(1.53 \pm 0.10) \times 10^{27}$ W [2 marks]

6. A spring with force constant k is oscillating on a frictionless horizontal surface with a mass m attached to its end. At any time t, the displacement of the mass from the equilibrium position is x. The amplitude of the oscillations is A.

When $x = \pm pA$, the kinetic energy of the mass is equal to the elastic potential energy stored in the spring. The value of p is exactly

O $p = 1/2$
O $p = 1/3$
O $p = (\sqrt{2})/2$
O $p = (\sqrt{3})/2$ [2 marks]

7. One mole of a monatomic ideal gas undergoes a cyclic sequence of processes as shown in the diagram (where V is the volume occupied and T is the temperature). The processes are labelled **I**, **II**, **III** and **IV** below.



Which of these statements are true?

1 Processes I and III occur at constant (but different) pressures
2 In Process II, the gas absorbs heat
3 In Process IV, the work done on the gas by the surroundings equals the heat released by the gas

O **1** and **2** only
O **1** and **3** only
O **2** and **3** only
O **1**, **2** and **3** [2 marks]

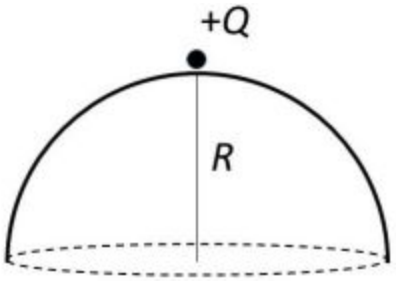
8. A person measures the depth of an empty water well by measuring the time interval between dropping a stone and receiving the sound of impact with the bottom of the well. The absolute uncertainty in his measurement of time is 0.01 seconds and he calculates the depth of the well to be 20 meters.

In his calculations he took g = 9.8 ms^{-2} and the speed of sound v = 330 ms^{-1}.

Neglecting the errors due to the precision of g and v, the percentage uncertainty in his measurement of the depth of the well is approximately

O 0.2 %
O 1 %
O 3 %
O 5 % [2 marks]

9. A point charge +*Q* is placed just outside an imaginary hemispherical surface of radius *R* as shown in the figure.



Which, if any, of these statements are true?

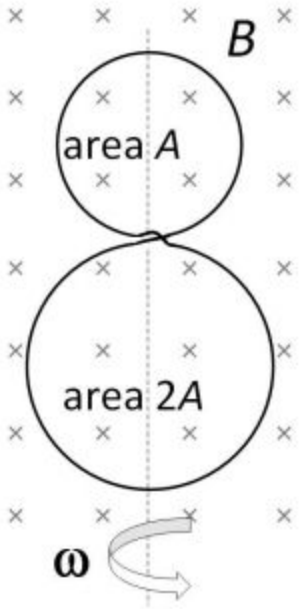
1 The component of the electric field perpendicular to the **flat** surface is constant over the surface

2 The circumference of the flat surface is an equipotential

3 If the flat surface is replaced with a flat, circular, negatively charged metal plate of radius *R* then there is no change in the electric field on the **curved** surface of the hemisphere at the instant it is replaced

O **1** only
O **2** only
O **3** only
O None of them [2 marks]

10. A circular insulated copper wire loop is twisted to form two loops of area A and $2A$ as shown in the figure. The entire loop lies in the same plane.



A uniform magnetic field **B** points into the plane of the paper. At time $t = 0$, the loop starts rotating about the common diameter as the axis with a constant angular velocity ω in the magnetic field.

Assuming that at the point of crossing the wires remain electrically insulated from each other, which of the following statements is true?

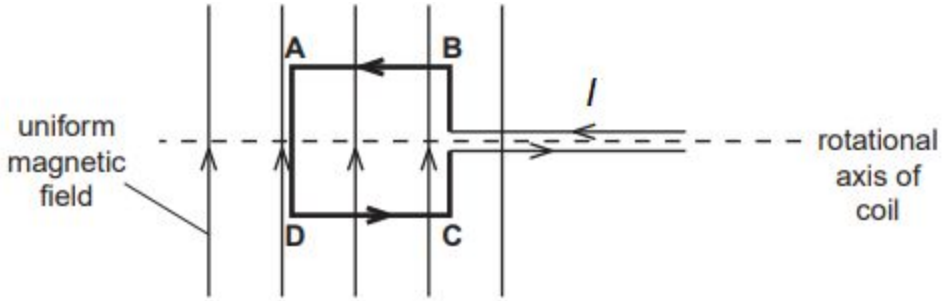
O The e.m.f. induced in the loop is proportional to the sum of the areas of the two loops.

O The rate of change of the flux is maximum when the plane of the loops is perpendicular to the plane of the paper.

O At any time t, the net e.m.f. induced due to both the loops is proportional to $\cos \omega t$.

O The amplitude of the maximum net e.m.f. induced due to both the loops is greater than the amplitude of maximum e.m.f. induced in the smaller loop alone. [2 marks]

11. A current-carrying rectangular coil is placed in a uniform magnetic field.



Initially the plane of the coil is parallel to the magnetic field which is also at right angles to the section **AB** of the coil.

Which of these would increase the torque of the coupled forces acting on **AB** and **CD** in the subsequent motion?

1 Increase the length of the wire in the section **AB** and **CD**

2 Increase the length of the wire in the section **AD** and adjust **BC** to maintain a rectangular coil

3 Increase the magnitude of the current *I*

O **1** and **2** only
O **1** and **3** only
O **2** and **3** only
O **1**, **2** and **3** [2 marks]

12. A radio transmitter transmits a signal at 600 MHz to a receiver 1 km away. In an attempt to double the strength of the signal at the receiver, a second antenna is added at the transmitter, 1 m away alongside the original one, and fed by the same signal.

An engineer notes that instead of improving reception, diffraction effects might actually make reception much worse.

Which of the following provides a valid argument to either support or refute the engineer's prediction?

O Diffraction effects would not be a problem because the waves are too low frequency to produce diffraction effects.

O Diffraction effects would not be a problem as the transmitting antennas are too far apart to produce diffraction effects.

O Diffraction effects will occur, but the maxima would be sufficiently close together that this would not be a problem.

O Diffraction effects could be a problem because the distance between the transmitting antennas is comparable to the wavelength. [2 marks]

13. The *Digest of UK Energy Statistics (2015)* reports that in the UK in 2014 the total amount of electricity generated was 3.4×10^5 GW h, and it also states that total electricity consumption was 3.0×10^5 GW h.

Which of the following is the main reason for the difference between the figures quoted for generation and consumption?

O Power stations in the UK are on average only about 88% efficient.
O Electrical appliances in the UK are on average only about 88% efficient.
O About 12% of the electricity generated is lost in the distribution network.
O The data on consumption are incomplete. [2 marks]

14. The largest source of error in the standard method to measure the resistivity of constantan electrical wire is typically due to

O Non-uniformity of the cross-sectional area of the wire.
O Increased resistance due to heating of the wire by thermal dissipation.
O Improper electrical contacts between the test wire and the circuit.
O Inaccurate measurement of the true length of the test wire. [2 marks]

15. A student wants to carry out an experiment to determine the input power to a small electric motor without using electrical meters. The motor is used to lift light loads at steady speeds and works at its maximum power at all times. The efficiency of the motor is known to be 15%. They plan to follow this method:

- Attach a slot mass of 100 g to the motor
- Use the motor to slowly lift the mass through a vertical height of 1.00 m at a constant speed
- Record the time taken (*t* s) for this to happen using a stopwatch and slow-motion camera to improve accuracy
- Add another 100 g mass and repeat for various masses
- Plot a graph of *m* in kg (*y*-axis) against *t* in s (*x*-axis) and obtain the gradient of the best fit line and calculate associated uncertainty
- Use the formula P_{input} = (*g*/0.15) * gradient to estimate the power input.

Which of the following comments about this method are true?

1 The power input obtained will be an underestimate of the true value.

2 The largest source of uncertainty in this method is due to the slot masses used (typical uncertainty: 5%)

3 The formula derived to calculate the power input is valid only when the motor is lifting the masses at a low speed.

O **1** and **2** only
O **1** and **3** only
O **2** and **3** only
O **1**, **2** and **3** [2 marks]

Section B: Standard Questions. You are advised to spend **most** of your time in Section A.

16.

a. Define the terms

i) *simple harmonic motion* (SHM). [1 mark]

ii) *resonance* of a mechanical system. [1 mark]

b. A simple pendulum is an example of a system that, under certain assumptions, undergoes SHM.

i) Give **two** assumptions that must be made about the pendulum in order for the system to exhibit the characteristics of SHM. [2 marks]

ii) Suppose that the top of the string on the pendulum is attached to a light circular ring which is free to slide on a frictionless rail.

Explain why the ring now also undergoes SHM. [2 marks]

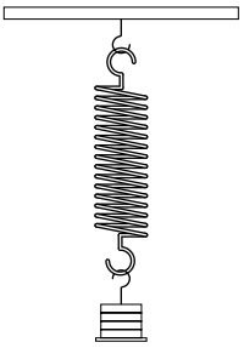
c. A student wishes to investigate whether the period of oscillation of a simple pendulum is constant (i.e. *isochronous*) for all angles of swing. Describe how the student should carry out the investigation.

Include the following in your description:

- a sketch of the apparatus with angle of swing labelled;
- details of how the measurements would be made;
- how these results would be used to form a conclusion;
- the major difficulty likely to be encountered and how this might be overcome.

[5 marks]

d. Consider again the original spring-mass system:



The spring is attached to a fixed support at its upper end. When the masses are pulled down a short distance from the equilibrium position and released they oscillate vertically with simple harmonic motion. The frequency *f* of these oscillations depends on the mass *m* of the masses.

Two students make different predictions about the relationship between *f* and *m*. One suggests *f* is proportional to $1/m$ and the other believes *f* is proportional to $1/\sqrt{m}$.

Describe how you would test experimentally which prediction is correct.

Include in your answer:

- the measurements you would take;
- how you would use these measurements to test each prediction;
- ways of making the test as reliable as possible. [4 marks]

e. List the different types of energy involved in the oscillations of this mass-spring system. Describe the energy changes when the masses move from the lowest point of the oscillation to the highest point.

In your answer you should use appropriate technical terms spelled correctly.

[4 marks]

[Total for Q16: 19 marks]

17. In experiments performed in the early 1900s carried out to determine the nature of atoms, alpha particles were fired at thin metal foils. The results had profound consequences and led directly to the foundation of particle physics.

a. Describe the nature and range of the **three** forces acting on the protons and neutrons in the nucleus. [5 marks]

b. Describe how the alpha-particle scattering experiments provide evidence for the existence, charge and size of the nucleus. In your answer, you should make clear how the conclusions link with observations. [5 marks]

[Total for Q17: 10 marks]

18. You are provided with a small bottle of cooking oil and standard physics laboratory equipment. With the help of a labelled diagram, describe an electrical experiment to determine the specific heat capacity of the oil.

State **two** sources of uncertainty in your measurements and discuss how these could be reduced.

In your answer, you should use appropriate technical terms spelled correctly.

[6 marks]

[Total for Q18: 6 marks]

19. An electron in a particle accelerator experiences a constant force. According to one student, the acceleration of the electron should remain constant because the ratio of force to mass does not change. In reality, experiments show that the acceleration of the electron decreases as its velocity increases.

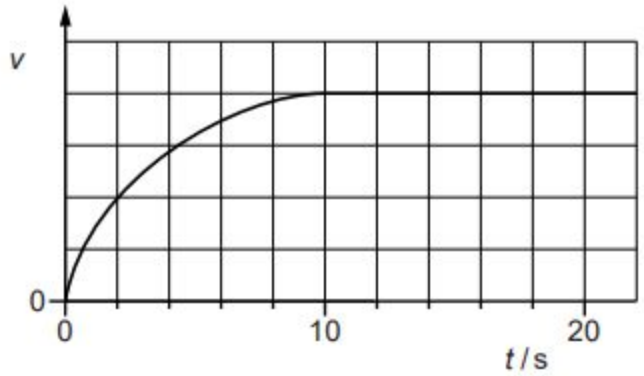
Describe what can be deduced from such experiments about the nature of accelerated electrons. [2 marks]

[Total for Q19: 2 marks]

20.

a. Aristotle and Galileo had different ideas about the way in which objects fall to the ground. Compare these ideas. [2 marks]

b. Below shows the graph of velocity against time for a parachutist falling vertically through the air. The initial vertical velocity is zero.



i) Explain how you can tell from the graph that the drag force experienced by the parachutist increases up to a limit. [2 marks]

ii) It is hypothesised that the magnitude of the drag force *F* acting on the parachutist at any instant during their fall is dependent on:

- the speed of the parachutist, *v*
- the surface area of the parachutist exposed to the air below, *A*
- the density of the air, *ρ*

such that a relationship of the form $F = kv^a A^b \rho^c$ holds, where *k* is a unitless constant and *a*, *b*, *c* are unknown integer exponents of the independent variables.

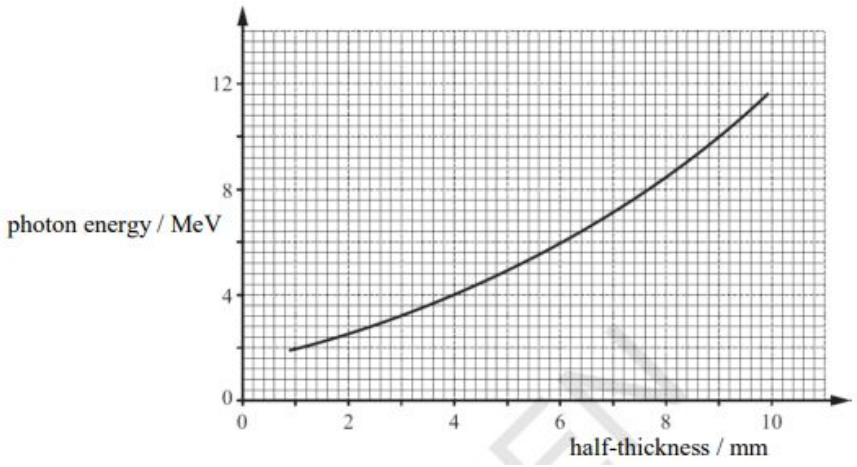
By considering the units and dimensions on both sides of the above equation, deduce the values of *a*, *b* and *c*. [5 marks]

iii) Suggest the significance of the constant *k* in the above equation. [1 mark]

iv) Explain why your analysis in part ii) does not prove the validity of the equation. [1 mark]

[Total marks for Q20: 11 marks]

21. Lead of different thicknesses can be used to investigate the absorption of gamma photons from a radioactive source. Below shows a graph of gamma photon energy against the *half-thickness* of lead. Half-thickness is defined as the thickness of lead which will reduce the original count-rate by half.

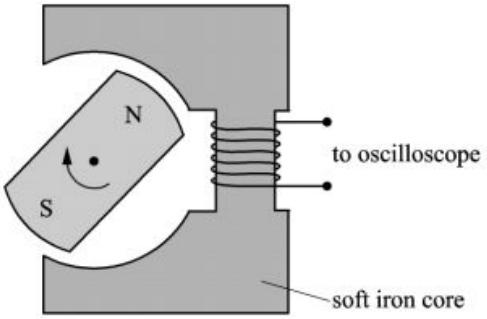


Describe an experiment that can be carried out to determine the half-thickness of lead and how you would use your results with the graph to determine the energy of a gamma photon from a radioactive gamma source in your laboratory.

Include the equipment used, any safety precautions necessary and how the quality of the results may be improved. [6 marks]

[Total for Q21: 6 marks]

22. The figure shows a simple AC generator being tested by electrical engineers.



It consists of a magnet, on the shaft of a variable speed motor, being rotated inside a cavity in a soft iron core. The output from the coil, wound on the iron core, is connected to an oscilloscope.

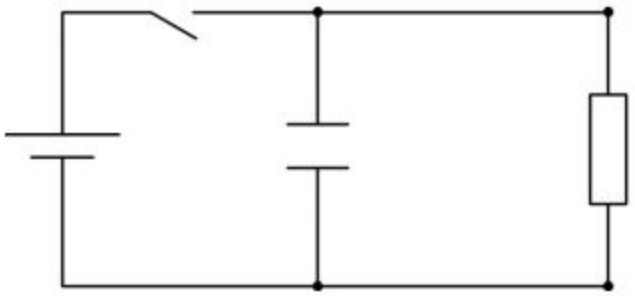
a. i) The oscilloscope shows the output voltage of the coil. Name the type of curve you would expect to see on the oscilloscope trace. [1 mark]

ii) State Faraday's law of induction, in the context of a coil. [1 mark]

b. Use the apparatus above to plan an experiment to validate Faraday's law of electromagnetic induction. In your description include how the data is collected and analysed. [6 marks]

[Total for Q22: 8 marks]

23. Below shows a standard RC (resistor-capacitor) circuit.



The charge stored *Q* on the capacitor of capacitance *C* at a time *t* after discharging through a resistance *R* from an initial charge Q_0 is given by the equation $Q = Q_0 \cdot \exp(-t/RC)$

i) Show that *RC* has units of time. [2 marks]

ii) Describe how the time constant of this circuit can be determined experimentally in the laboratory. [3 marks]

iii) Propagation of an uncertainty Δx through an exponential function e^x requires a different approach from typical procedures. Using a mathematical technique known as *power series expansion*, it is possible to express the exponential function as follows:

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + x + \frac{x^2}{2} + \frac{x^3}{6} + \frac{x^4}{24} + \frac{x^5}{120} + \ldots$$

The more terms on the right are calculated, and the closer x is to zero, the closer the approximation gets to the true value. In order to propagate uncertainties, the sequence on the right-hand side is typically truncated to the first two terms only.

Using this convention, calculate, with the associated uncertainty, the charge remaining on a capacitor (capacitance: 75 ± 3 μF, initial charge: 2.4 ± 0.1 nC) at a time of 0.20 seconds (to 2 significant figures) after discharging commences through a resistance of 40 ± 1 kΩ. [3 marks]

[Total for Q23: 8 marks]

End of Questions

Question Sources:

Q3:	OCR A-Level Physics Past Paper
Q6, 7, 8, 9, 10:	IIT Advanced Past Paper (Physics)
Q12, 13:	ENGAA Past Paper
Q16c, d, e:	OCR A-Level Physics Past Paper
Q17, 18, 19, 20a:	OCR A-Level Physics Past Paper
Q20b:	AQA A-Level Further Mathematics Paper (Mechanics)
Q21, 22:	OCR A-Level Physics Past Paper
Q23:	IIT Advanced Past Paper (Physics)