OCR A-Level Physics: Practice Paper 1

Focus: Mathematical skills

Difficulty: Hard

Time: 2 hours 15 minutes

Marks:

Section A (multiple choice): 15 marks (25 minutes)

Section B (standard questions): 85 marks (1 hour 50 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:

Motion, Forces, Energy, Power, Electromagnetism, Waves, Thermal Physics, Circular Motion

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 25 minutes in Section A.

1. The base SI units of energy are

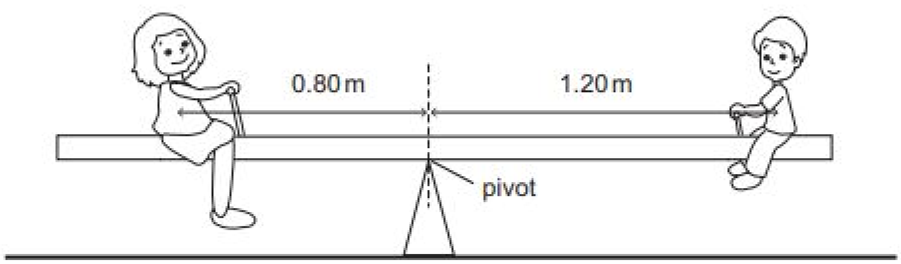
O J
O N m
O kg m s^{-2}
O kg m^2 s^{-2} [1 mark]

2. A car is driving along a road and approaches a 49 m long bridge and begins accelerating at 0.80 ms^{-2} when it enters the bridge. The car reaches the end of the bridge with a speed of 26 ms^{-1}.

The time taken to drive across the bridge was

O 1.8 s
O 1.9 s
O 4.0 s
O 4.4 s [1 mark]

3. A plank of non-uniform density which has a mass of 15 kg is used to make a see-saw. A pivot is placed under the centre of the plank:

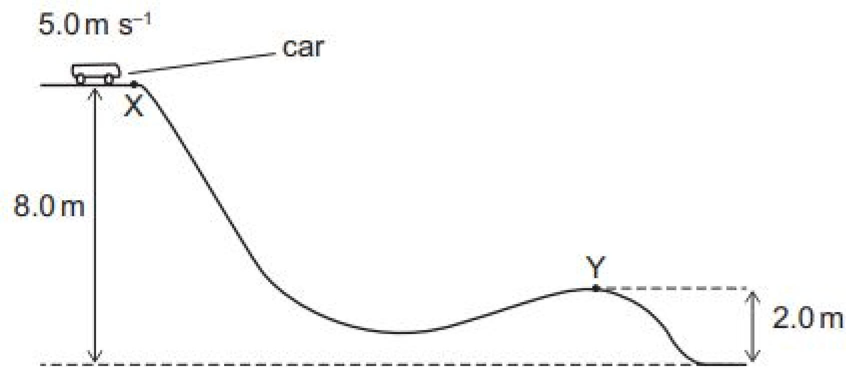


A boy of mass 35 kg sits at one end of the plank with his centre of gravity 1.20 m from the pivot. The see-saw balances when a woman of mass 60 kg sits on the plank on the other side of the pivot. Her centre of gravity is 0.80 m from the pivot.

The position of the centre of gravity of the plank is

O 0.20 m to the left of the pivot
O 0.20 m to the right of the pivot
O 0.40 m to the left of the pivot
O 0.40 m to the right of the pivot [1 mark]

4. A car of mass 200 kg on a fairground ride travels at a speed of 5.0 ms^{-1} at point *X*. The car is allowed to move down a sloping section of track without any energy input. The heights above the ground of points *X* and *Y* are shown. When the car reaches point *Y* its speed is 9.0 ms^{-1}



How much energy is transferred in overcoming resistive forces as the car travels from *X* to *Y*?

O 3900 J
O 6400 J
O 7900 J
O 10400 J [1 mark]

5. The area under a stress-strain curve for a particular material represents the

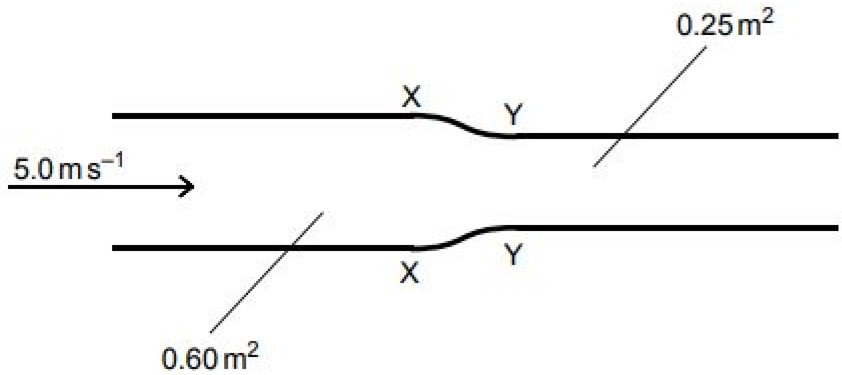
O Young modulus of the material
O Elastic potential energy stored per unit volume of material
O Extension per unit cross-sectional area of material
O Energy lost to the surroundings as heat [1 mark]

6. An object is accelerating under the action of a constant resultant force. At time *T*, the particle has a momentum of 30 Ns and a kinetic energy of 150 J.

The mass of the particle is

O 2 kg
O 3 kg
O 5 kg
O 6 kg [1 mark]

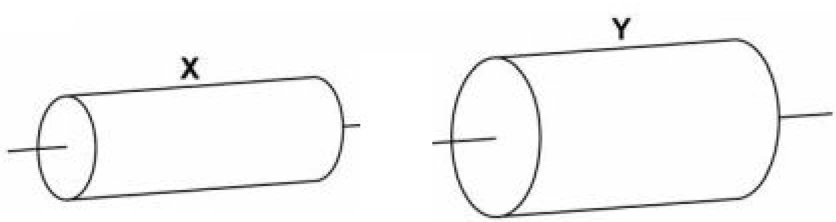
7. Oil of density 800 kg m^{-3} is being pumped through a pipe of cross-sectional area 0.60 m^2 at a speed of 5 ms^{-1}. Between points *X* and *Y*, the oil passes through a contraction to a new cross-sectional area of 0.25 m^2 .



The resultant force exerted on the oil as it passes from *X* to *Y* is

O 7000 N to the right
O 17000 N to the right
O 7000 N to the left
O 17000 N to the left [1 mark]

8. The two resistors **X** and **Y** shown below are both uniform cylinders of equal length made from the same conducting putty material.

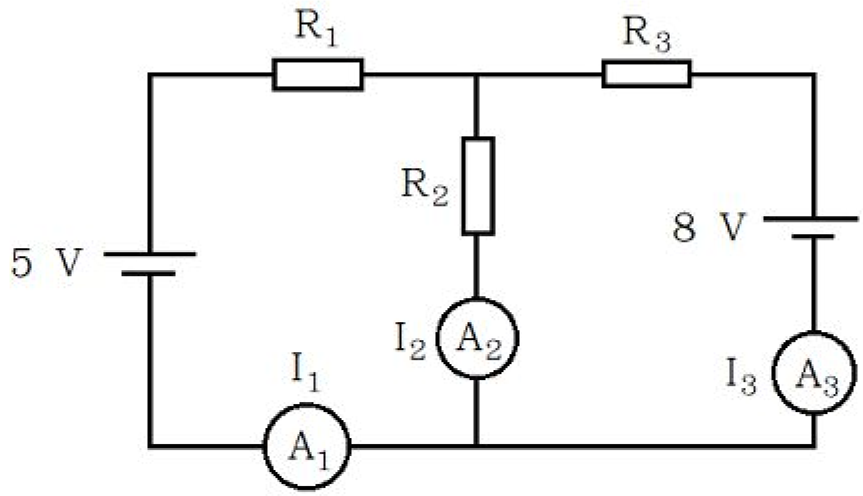


The diameter of **Y** is twice that of **X**. The resistance of **Y** is *R*.

If **X** and **Y** are connected in parallel, the total resistance is

O 4/3 *R*
O 4/5 *R*
O 3*R*
O 4*R* [1 mark]

9. An electrical circuit is set up as shown below



Resistors R_1 , R_2 and R_3 have resistances 2 Ω, 1 Ω and 4 Ω respectively. Ammeters A_1 , A_2 and A_3 measure currents of I_1 , I_2 and I_3 in amps respectively.

Which of these equations may **not** be obtained by applying Kirchhoff's second law to this circuit?

(Assume that all readings from the ammeters are positive.)

O $2I_1 + I_2 = 5$
O $2I_1 + 4I_3 = 13$
O $I_2 + 4I_3 = 8$
O $4I_3 - 2I_1 = 3$ [1 mark]

10. A transverse wave with an amplitude of 4.0 cm and a frequency of 10 Hz travels along a rope at a speed of 2.4 ms^{-1} .

What is the total distance travelled by a particle in the rope in a time of 20 s?

O 32 m
O 48 m
O 80 m
O 96 m [1 mark]

11. When a saucepan of water is heated from below, convection currents form and transfer heat through the liquid.

A The mass of a fixed volume of the water increases.
B The density of a fixed mass of the water decreases.
C The volume of a fixed mass of the water increases.

Which statements help to explain how convection currents are formed?

O **A** and **B** only
O **B** and **C** only
O **A** and **C** only
O **A**, **B** and **C** [1 mark]

12. A person twirls a circular ring (of mass M and radius R) near the tip of their finger as shown in Figure 1. In the process the finger never loses contact with the inner rim of the ring. The finger traces out the surface of a cone, shown by the dotted line. The radius of the path traced out by the point where the ring and the finger is in contact is r. The finger rotates with an angular velocity ω_0.

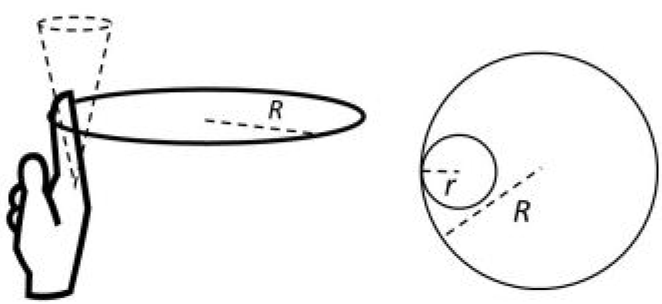


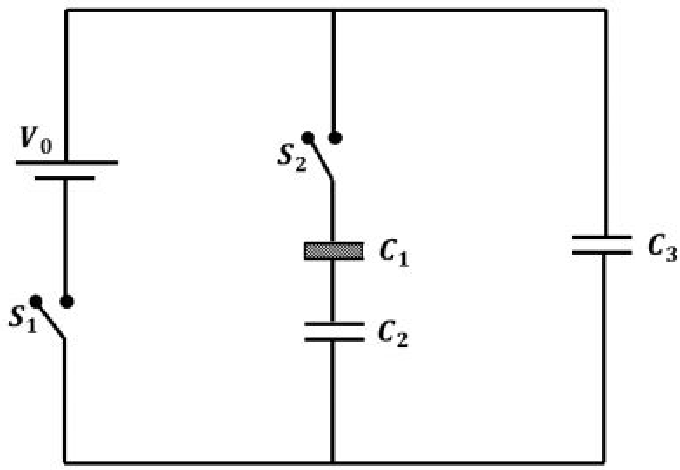
Figure 1 Figure 2

The rotating ring rolls without slipping on the outside of a smaller circle described by the point where the ring and the finger is in contact (Figure 2).

The kinetic energy of the ring is

O $1/2\ M\omega_0^2R^2$
O $M\omega_0^2R^2$
O $1/2\ M\omega_0^2(R - r)^2$
O $3/2\ M\omega_0^2(R - r)^2$ [1 mark]

13. Three identical capacitors C_1 , C_2 and C_3 have a capacitance of 1.00 μF each and they are uncharged initially. They are connected in a circuit as shown in the figure and C_1 is then filled completely with a dielectric material of relative permittivity ϵ_r.



The cell electromotive force V_0 = 8.00 V. First the switch S_1 is closed while the switch S_2 is kept open. When the capacitor C_3 is fully charged, S_1 is opened and S_2 is closed simultaneously. When all the capacitors reach equilibrium, the charge on C_3 is found to be 5.00 μC.

The relative permittivity ϵ_r of the dielectric material in capacitor C_1 is

O 1.33
O 1.50
O 1.60
O 1.67 [1 mark]

14. Two radioactive sources *X* and *Y* have half-lives of 4.8 hours and 8.0 hours respectively. Both decay directly to form only stable isotopes. The activity of a sample of the source *X* is 320 Bq, and the activity of a sample of the source *Y* is 480 Bq. The two samples are now combined into a single substance. What is the activity of the combination of *X* and *Y* 24 hours later?

O 25 Bq
O 50 Bq
O 55 Bq
O 70 Bq [1 mark]

15. ^{131}I is an isotope of iodine that β-decays to a stable isotope of xenon with a half-life of 8 days. A small amount of a serum labelled with ^{131}I is injected into the blood of a person. The activity of the amount of ^{131}I injected was 2.4×10^5 Bq. It is known that the injected serum will get distributed uniformly in the bloodstream in less than half an hour.

After 11.5 hours, 2.5 ml of blood is drawn from the person's body, and gives an activity of 115 Bq.

The total volume of blood in the person's body is

O 1.0 litres
O 1.4 litres
O 3.9 litres
O 5.0 litres [1 mark]

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

16. A boy is standing over a ledge at the top of a 10 m tower, with a girl standing at the bottom. The boy throws a stone vertically upwards with a speed of 11 ms^{-1}.

1.5 seconds later, the girl also throws a stone vertically upwards, with a speed of 10 ms^{-1}. They both then immediately step clear of the falling stones.

The stones collide in mid-air.

a. Calculate the time taken between the boy throwing his stone and the stones colliding in the air. [6 marks]

b. Calculate the height above the ground at which the stones collide. [2 marks]

c. Calculate the speed at which the stones collide, **relative to each other.**

[4 marks]

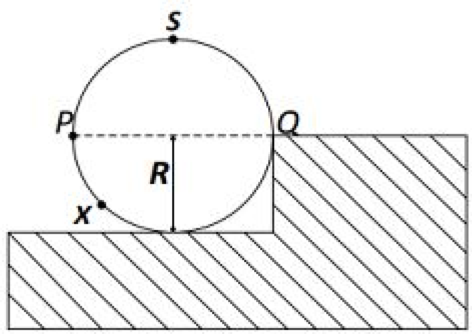
d. State **two** assumptions you have made in order for your calculations to be valid.

[2 marks]

[Total for Q16: 14 marks]

17. A wheel of radius R and mass m is placed at the bottom of a fixed step of height R as shown in the figure. A constant force F is continuously applied on the surface of the wheel so that it just climbs the step without slipping.

P, Q, S and X are points on the circumference of the wheel.



a. i) Define **torque**. [1 mark]

ii) Suppose that F is directed tangent to the wheel at P.

Explain why the torque T about Q remains constant as the wheel climbs. [1 mark]

b. Consider again the torque T about Q. Describe and explain what happens to the wheel when

i) F is applied normal to the circumference at X [2 marks]

ii) F is applied normal to the circumference at P [2 marks]

iii) F is applied tangent to the circumference at S [2 marks]

[Total for Q17: 8 marks]

18. A car of mass 1250 kg has a maximum speed of 40 ms^{-1} when travelling on a straight horizontal race track. The maximum power output of the car's engine is 48 kW.

The total resistance force to the car's motion at any moment can be modelled as being proportional to the car's speed at that moment.

a. i) State Newton's First Law. [1 mark]

ii) Define *power*. [1 mark]

iii) Use Newton's First Law to identify and describe the relationship between the forces acting on the car when it travels at its maximum speed. [1 mark]

b. Calculate the maximum possible acceleration of this car when it travels at 25 ms^{-1} on the same race track. [6 marks]

c. The same car now descends a hill angled at 4.0° to the horizontal.

Assuming that the total resistive force remains proportional to the speed, calculate the new top speed of the car as it descends the hill. [4 marks]

d. The engine of the car is not 100% efficient.

i) Define the **efficiency** of a mechanical system. [1 mark]

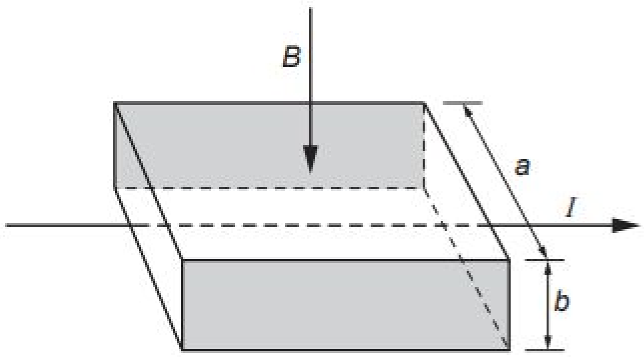
ii) The combustion engine of the car consists of 4 cylinders which each perform engine cycles (revolutions) at a certain rate. In each cycle, a total of 120 J of energy is released from the system.

When the engine is working at its maximum rate of 48 kW, the cylinders are each operating at 7000 revolutions per minute.

Calculate the efficiency of this engine. [3 marks]

[Total for Q18: 17 marks]

19. A small thin rectangular slice of semiconducting material has width *a* and thickness *b* and carries a current *I*. The current is due to the movement of electrons. Each electron has charge –*e* and mean drift velocity *v*. A uniform magnetic field of flux density *B* is perpendicular to the direction of the current and the top face of the slice as shown in the diagram below.



As soon as the current is switched on, the moving electrons in the current are forced towards the shaded rear face of the slice where they are stored. This causes the shaded faces to act like charged parallel plates. Each electron in the current now experiences both electric and magnetic forces. The resultant force on each electron is now zero.

a. State and explain the variation in the number of free charge carriers in semiconductors at different temperatures and the resulting effect on their electrical resistance. [3 marks]

b. Write the expressions for the electric and magnetic forces acting on each electron and use these to show that the magnitude of the potential difference *V* between the faces is given by $V = Bva$. [3 marks]

c. In a particular experiment, the material used contained 1.2×10^{23} conducting electrons per cubic metre. It was determined that a = 5.0 mm, b = 0.20 mm, I = 60 mA, and B = 80 mT.

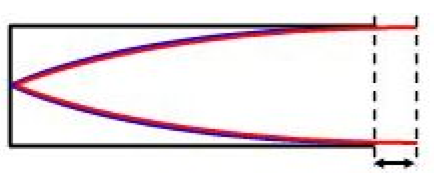
Use this data to calculate the mean drift velocity v of electrons within the semiconductor, and hence the potential difference V between the shaded faces of the slice. [4 marks]

[Total marks for Q19: 10 marks]

20. In an experiment to measure the speed of sound by a resonating air column, a tuning fork of frequency 500 Hz is used. The length of the air column is varied by changing the level of water in the resonance tube. Two successive resonances are heard at air columns of length 48.9 cm and 82.1 cm.

a. Use the data obtained to estimate the speed of sound in air. [4 marks]

b. A more in-depth analysis is then performed to take into account *end effects* of the resonance tube. End effects occur when an antinode of the acoustic wave is actually located slightly beyond the open end of the pipe by a distance *d*. The figure shows the end correction for a resonance tube at the fundamental mode of an acoustic wave with wavelength λ:



i) Assuming $d \ll \lambda$, what is the appropriate end correction for this experiment? [3 marks]

ii) Which harmonic did the resonance at length 48.9 cm correspond to? [1 mark]

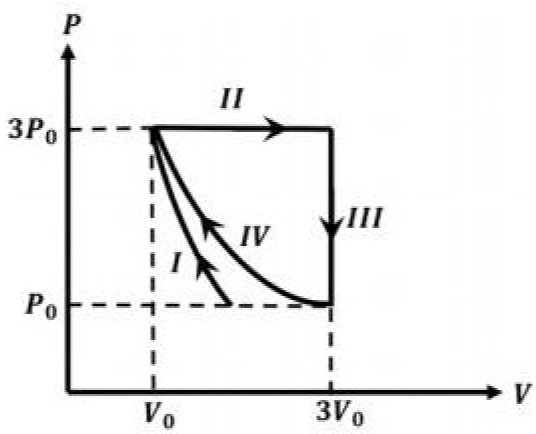
[Total marks for Q20: 8 marks]

21. The thermodynamics of physical gases can be simplified by modelling the gas as *ideal*. One assumption for an ideal gas is that there are no forces between the particles in the gas.

a. Outline **three** other assumptions made when modelling a gas as ideal.

[3 marks]

b. The diagram below shows how the pressure *P* and volume *V* of one mole of a monatomic ideal gas vary as it undergoes a sequence of four processes (labelled I, II, III and IV below).



i) Process I is known as an *adiabatic* process. This means that no heat is absorbed or released by the gas. Before starting Process I, the temperature of the gas was 298 K.

Process I involves compressing the gas rapidly in a piston. The piston is pushed down by 30 cm due to a constant force of 4800 N. The molar mass of the gas is 2.6×10^{-2} kg mol^{-1}.

Calculate the root-mean-square (r.m.s.) speed of the particles in the gas after it has undergone Process I. [5 marks]

ii) It is given that P_0 is atmospheric pressure (101 kPa) and $V_0 = 0.10\ m^3$.

Calculate the work done by the gas on its surroundings in Process II.

[2 marks]

iii) Give the relationship between pressure and temperature in Process III.

[1 mark]

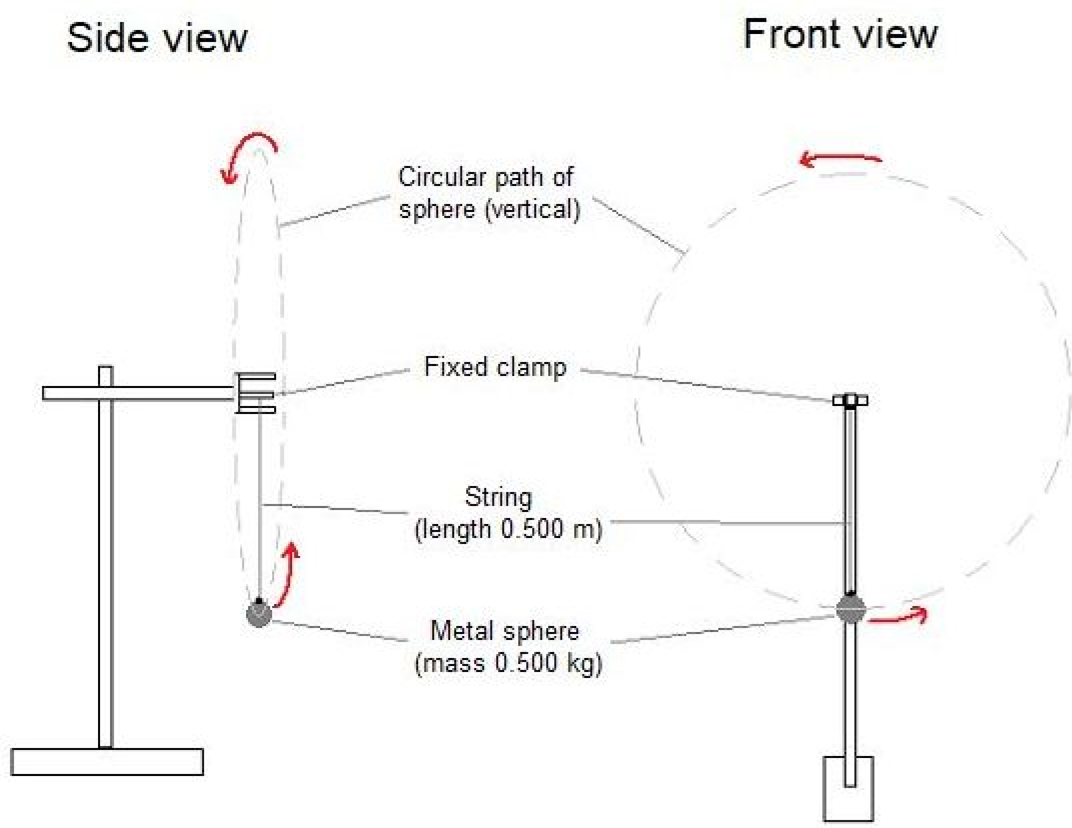
iv) Explain how you can tell that Process IV takes place at constant temperature.

[2 marks]

[Total for Q21: 13 marks]

22. A student clamps a light inextensible string of length 0.500 m with a metal sphere of mass 0.500 kg at the other end. The sphere hangs vertically below the clamp. The student then sets the sphere in motion with an initial velocity in the direction perpendicular to the clamp so that it moves in a vertical plane and completes full circles around the clamp as shown in the diagram below.

You may assume the prongs of the clamp do not interfere with the motion of the string, maintaining a constant radius of rotation throughout.



On the subsequent revolution, a newton-meter shows that the tension in the string when the sphere is at the bottom of the circle was 5 times the tension in the string when the sphere is at the top of the circle.

a. By considering the forces acting on the sphere and its energy, find the tension in the string when the sphere was at the bottom of the circle. You may assume no resistive forces act on the sphere. Give your answer in newtons. [8 marks]

b. The student repeats the procedure. He sets the sphere in the same motion at an initial speed u ms^{-1}. This time, the string goes slack during the motion and therefore the sphere does not complete the circular path.

Find the largest value of u so that the string goes slack as described.

[7 marks]

[Total for Q22: 15 marks]

End of Questions

Question Sources

Q3, 4:	NSAA Past Paper (Advanced Mathematics and Physics)
Q6:	IIT Mains Past Paper (Physics)
Q7:	ENGAA Past Paper
Q8:	AQA A-Level Physics Past Paper
Q10, 11:	ENGAA Past Paper
Q12, 13:	IIT Advanced Past Paper (Physics)
Q14:	ENGAA Past Paper
Q15:	IIT Advanced Past Paper (Physics)
Q17:	IIT Advanced Past Paper (Physics)
Q18b, c:	AQA A-Level Further Mathematics Past Paper (Mechanics)
Q19:	OCR A-Level Physics Past Paper
Q20, 21:	IIT Advanced Past Paper (Physics)
Q22:	AQA A-Level Further Mathematics Past Paper (Mechanics)