Name	Index Number

Anglo-Chinese School

(Independent)

END-OF-YEAR EXAMINATION 2024

YEAR 5 IB DIPLOMA PROGRAMME

PHYSICS (HIGHER LEVEL) **PAPER 2**

Wednesday **18 September 2024** **2 hours 30 minutes**

INSTRUCTIONS TO STUDENTS

Write your index number in the box provided on the top right corner of this page.

Do not open this booklet until you are told to do so.

There are 10 questions in this paper.
Answer **all** the questions.

INFORMATION FOR STUDENTS

The number of marks is given in brackets [ ] at the end of each question or part question.
The maximum mark for this examination paper is [90 marks].

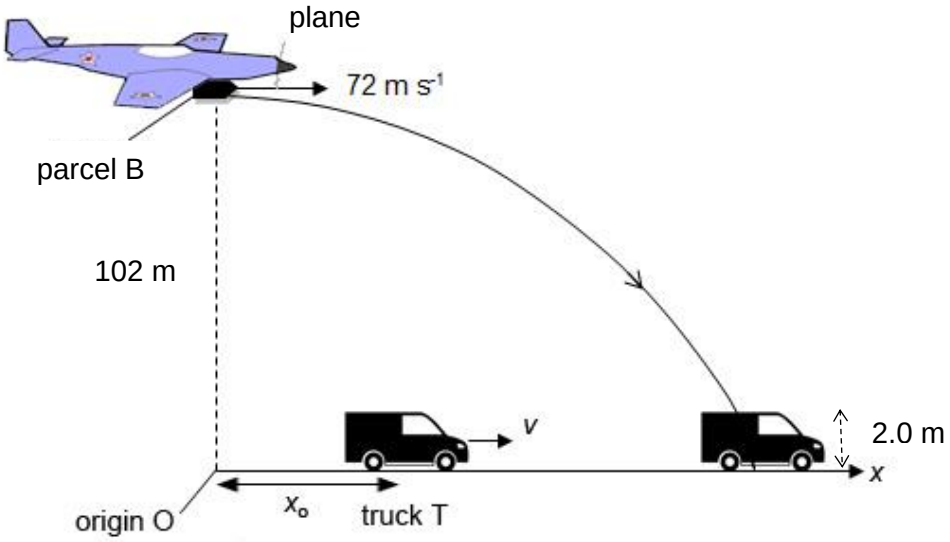
Calculators are allowed for this paper.

Data booklet will be provided.

Marks Awarded	
Section	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Sig. Fig.	
Units	
TOTAL SCORE	

Answer all the questions in the spaces provided.

1. A plane is flying horizontally at a speed of 72 m s^{-1}. It is at a height of 102 m above the ground. When the plane is flying over an origin O, a parcel B is released. After some time, parcel B strikes a truck T of height 2.0 m, which is moving along a level road with a constant speed *v*. At the instant parcel B is released, the truck T is at a distance x_o = 125 m from origin O.

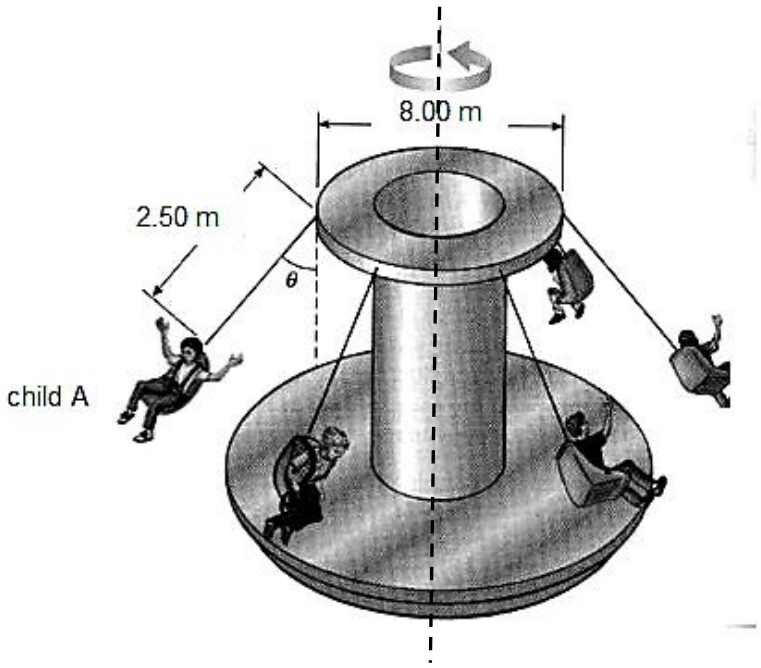


(a) Calculate the time of flight of parcel B before it strikes truck T. [3]

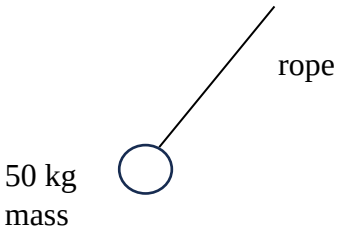
(b) On the same axes, sketch two graphs to show the variation with time t of the horizontal displacement x from the origin for parcel B and truck T. Label the graphs B and T respectively. Time $t = 0$ is the instant when parcel B is released from the plane. [2]

(c) Using the graphs in part (b) or otherwise, calculate the speed v of truck T. [2]

2. An amusement park ride consists of a rotating circular platform 8.00 m in diameter. The child and the seat can be considered as a mass of 50 kg suspended at the end of 2.50 m light rope. When the system rotates, the rope make an angle θ of 28.0° with the vertical. Air resistance is negligible.



(a) In the space below, draw a labelled free-body diagram of child A and seat. The child and seat can be considered as a 50 kg mass. [2]

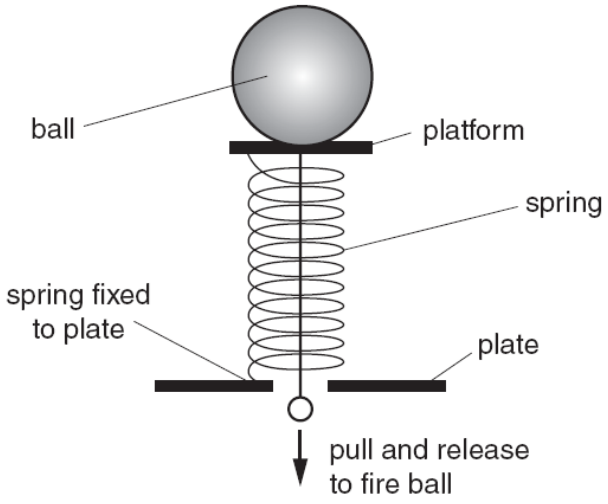


(b) Show that the radius of the circular motion of each child and seat is estimated to be 5.2 m. [2]

(c) Calculate the speed of each child and seat. [3]

(d) Calculate the tension in each rope. [2]

3. The diagram shows a mechanism for firing a ball of mass 25 g vertically into the air. The spring has a force constant of 75 N m^{-1}. The ball is placed on the platform at the top of the spring. Assume both the spring and the platform have negligible mass and air resistance is neglible.



(a) The spring is compressed by 0.085 m. Calculate the force exerted by the compressed spring on the ball immediately after the spring is released. [2]

(b) Calculate the maximum height gained by the ball. The height is measured from the position of the platform when the spring is compressed by 0.085 m. [2]

(c) State and explain the effect of the maximum height if air resistance is not negligible. [2]

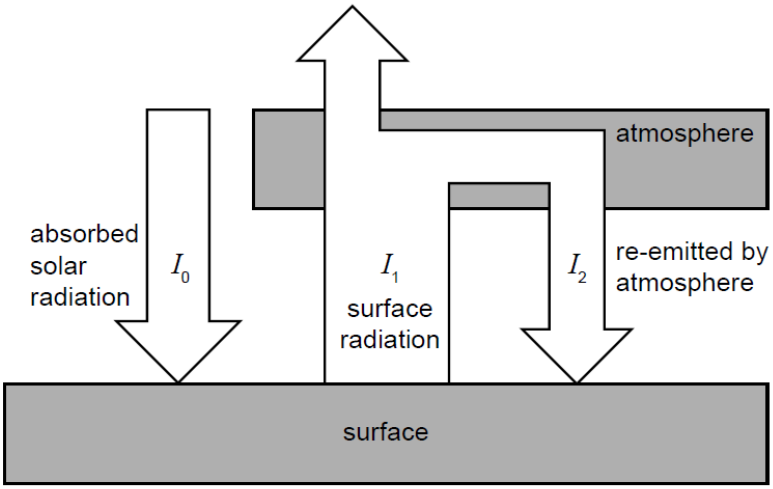
4. (a) A small iron ball of mass 24 g is heated in a Bunsen flame for about one minute. The iron ball is then quickly transferred to a 40 g copper calorimeter containing 300 g of water, at an initial temperature of 15.0 ^{o}C. Following the thermal exchange, the equilibrium temperature of the iron ball, and the water system is 22.0 ^{o}C. The specific heat capacities of iron, copper and water are respectively 0.451 J g^{-1} K^{-1}, 0.385 J g^{-1} K^{-1} and 4.200 J g^{-1} K^{-1}.

(i) Determine the temperature of the Bunsen flame. [2]

(ii) Besides thermal energy losses to the surroundings, state **one** other experimental error that will affect the value of (a)(i). [1]

(b) In a simplified model of energy balance of the Earth:

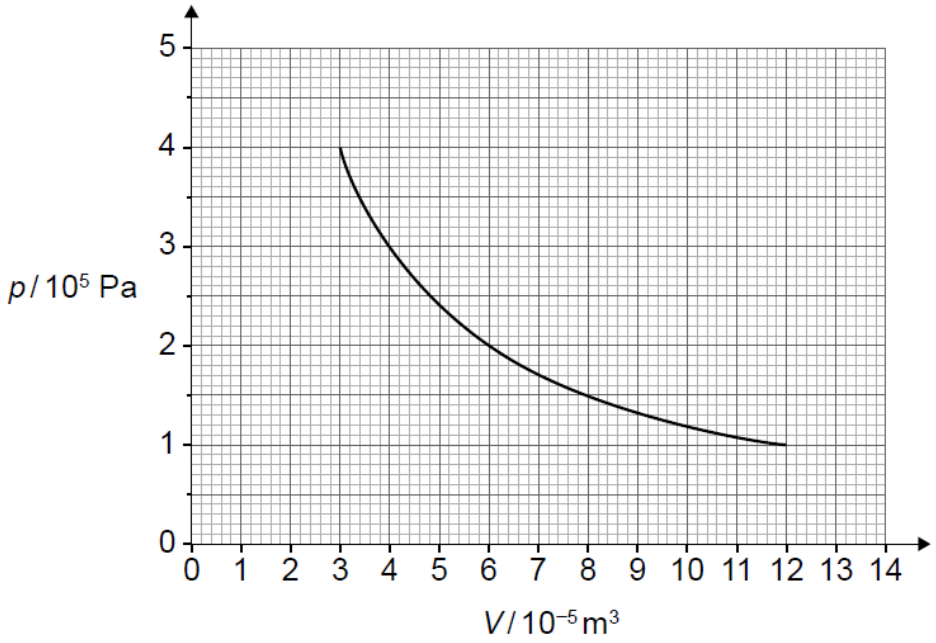
- the surface of the Earth absorbs incoming solar radiation of average global intensity I_o
- the surface emits thermal radiation of average intensity I_1
- some of the radiation emitted by the surface is absorbed by the atmosphere and re-emitted towards the surface. The average intensity of the radiation is I_2.



The following data are given.
I_o = 240 W m^{-2} ; I_2 = 150 W m^{-2}.

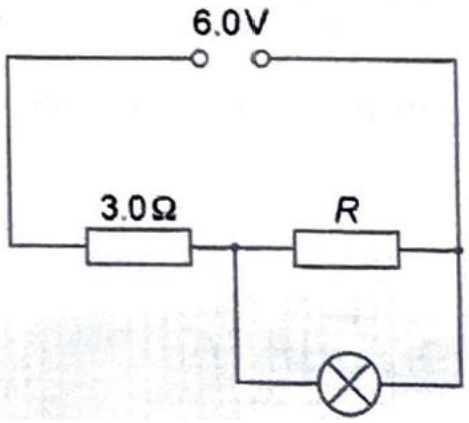
Determine the average temperature of the surface of the Earth according to this model, assuming that the surface behaves as a blackbody. [2]

(c) A fixed quantity of 4.5×10^{-3} mol of air is compressed at a constant temperature. The graph shows the variation of pressire p with volume V of the air.



Calculate the temperature of the gas. [2]

5. A lamp is connected in parallel to a resistor of resistance R. These are connected in series to a resistor of resistance 3.0 Ω and a power supply of e.m.f. 6.0 V and of negligible internal resistance, as shown below.



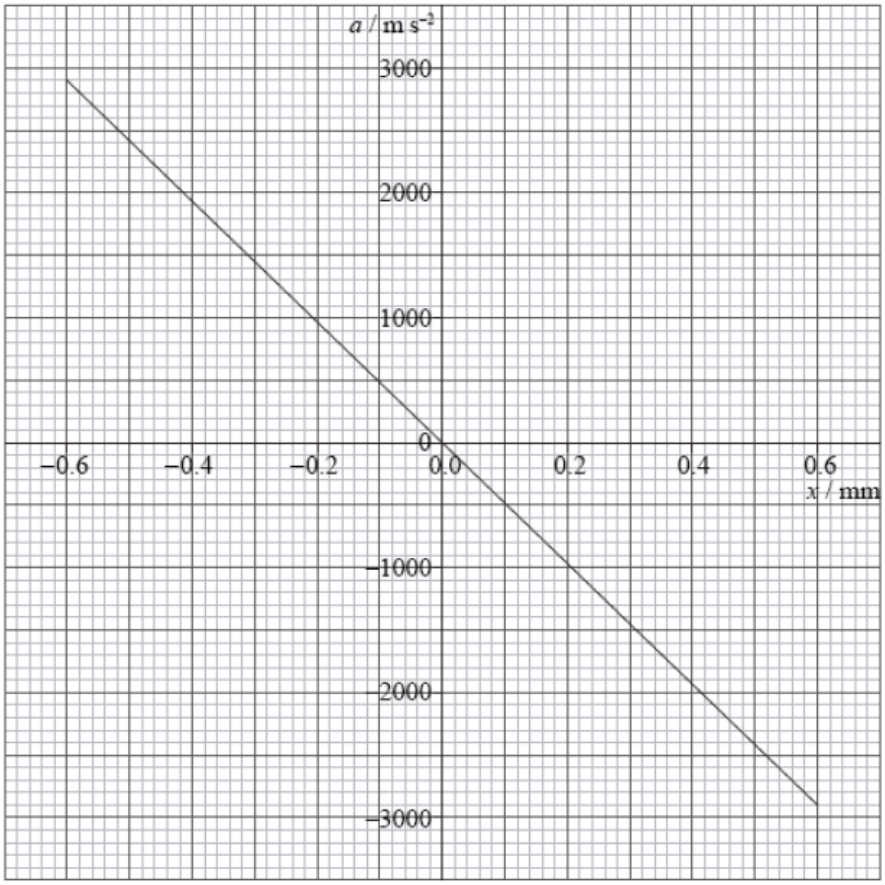
The current in the lamp is 0.30 A and its resistance is 5.0 Ω.

(a) Show that the resistance R is 1.25 Ω. [2]

(b) The power supply transfers 120 J of energy to the circuit. Determine the energy transferred in the lamp. [3]

(c) The lamp in the circuit is removed, and the power supply is replaced with one with an e.m.f. of 6.0 V and an internal resistance of r Ω. The current in the circuit is 1.176 A. Determine the value of r. [2]

6. (a) An object is vibrating in air.The variation with displacement x and the acceleration a of the particle is shown below.



(i) State two evidences why the graph indicates that the object is executing simple harmonic motion. [2]

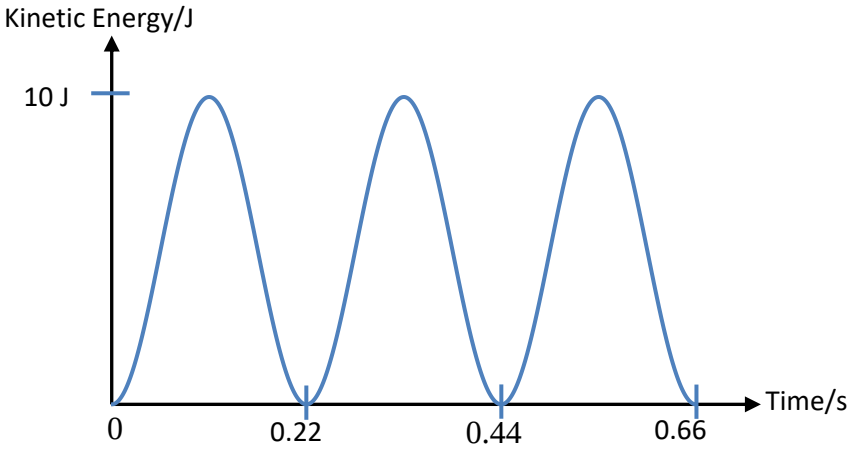
(ii) Use the data from the graph to show that the frequency of oscillation is 350 Hz. [2]

(b) A human eardrum has a surface area of 5.0×10^{-5} m^2. Lucy is listening to music through an in-ear monitor. The average sound intensity at Lucy's eardrum is 1.0×10^{-2} W m^{-2}.

(i) Determine the energy that her eardrum receives over a period of 5 min. [2]

(ii) State one assumption that you made. [1]

(c) A certain body of mass 300 g is oscillating in simple harmonic motion. The variation of its kinetic energy with time is shown in the graph below. The maximum kinetic energy possessed by the body is found to be 10 J.

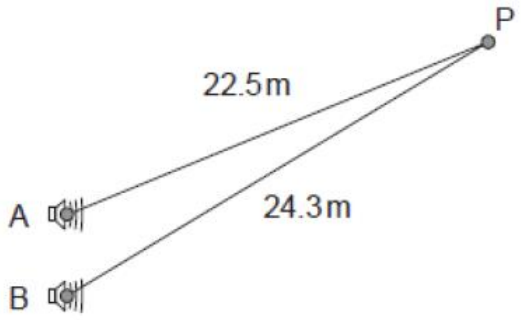


(i) State the period of oscillation. [1]

(ii) Determine the amplitude of oscillation. [3]

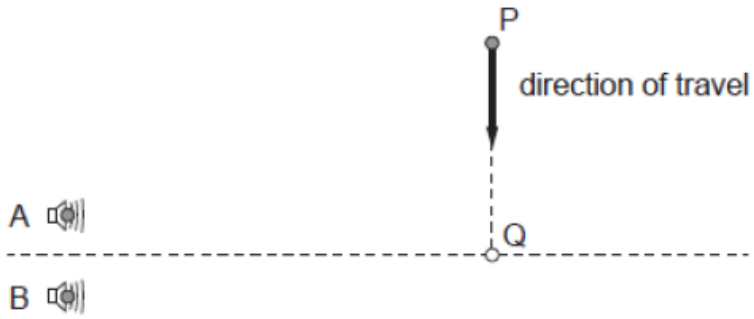
(iii) In the space provided below, sketch a graph (over one period) that shows the variation of displacement with time of the body. Label all important features of your graph, along with pertinent values of displacement and time. [2]

7. (a) Two loudspeakers, A and B are driven in phase and with the same amplitude at a frequency of 850 Hz. Point P is located 22.5 m from A and 24.3 m from B. The speed of sound is 340 m s^{-1}.



(i) Deduce that a minimum intensity of sound is heard at P. [3]

(ii) A microphone moves along the line from P to Q. PQ is normal to the line midway between the loudspeakers A and B.



The intensity of sound is detected by the microphone. Predict the variation of detected intensity as microphone moves from P to Q. [2]

(iii) When both loudspeakers are operating , the intensity of sound recorded at Q is I_0. Loudspeaker B is now disconnected. Loudspeaker A continues to emit sound with unchanged amplitude and frequency. The intensity of sound recorded at Q changes to I_A. Estimate the ratio $\frac{I_A}{I_0}$ [2]

(b) Light from a sodium discharge tube is incident normally upon a diffraction grating having 8.00 x10^5 lines per metre. The spectrum contains a double yellow line of wavelength 589 nm and 590 nm.

(i) Determine the angular separation of the two lines when viewed in the second order spectrum. [4]

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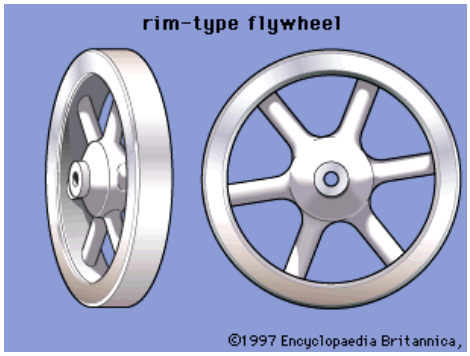
(ii) State why it is more difficult to observe the double yellow line when viewed in the first order spectrum. [1]

8. (a) As an alternative to a petrol engine, a prototype car is fitted with a flywheel. This is spun to a high speed at the start of a journey. To start the car the flywheel is connected to the drive wheels by a system of gears. The rotational energy stored in the flywheel is then used to propel the car. The flywheel has a moment of inertia of 90 kg m^2. Before each journey the flywheel is accelerated until it has an angular speed of 300 rad s^{-1}.



(i) State the factors which affect the moment of inertia of the flywheel. [2]

(ii) Assuming the angular acceleration to be uniform, determine the torque required to accelerate the flywheel to its maxmum angular speed in 2.5 minutes, to the appropriate significant figures. [3]

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(iii) Calculate the energy stored in the flywheel at the start of the journey. [2]

(iv) The average resistive force on the car during the journey is 400 N. Calculate the maximum distance the car can travel during this journey. [1]

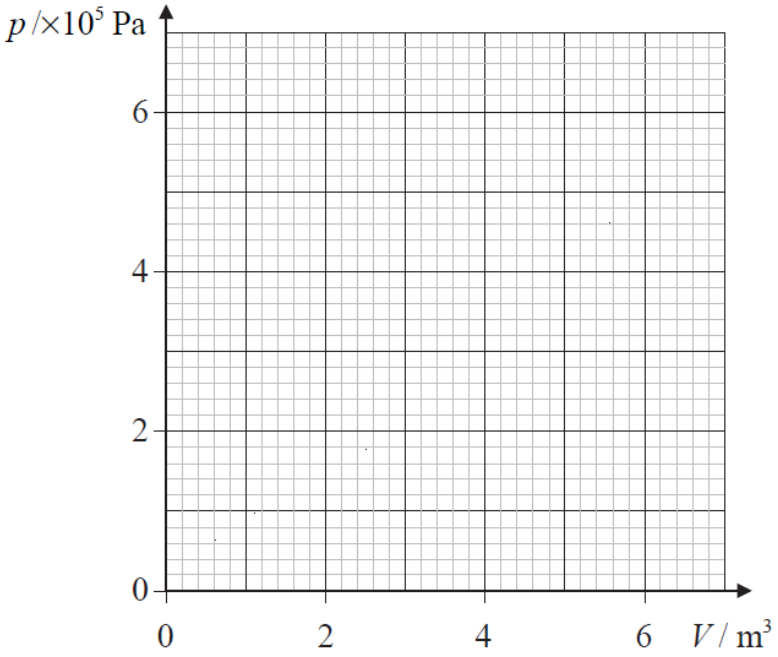
(b) (i) State the condition for the angular momentum of a system of rotating bodies to be conserved. [1]

(ii) A horizontal disc rotating freely about a vertical axis makes 90 revolutions per minute. A small piece of putty of mass 0.020 kg falls vertically on to the disc and sticks to it at a distance of 0.050 m from the axis of rotation. If the number of revolutions per minute is thereby reduced to 80, calculate the moment of inertia of the disc. [3]

9. (a) An ideal gas at an initial pressure of 4.0×10^5 Pa is expanded isothermally from a volume of 3.0 m^3 to a volume of 5.0 m^3 .

(i) Calculate the final pressure of the gas. [1]

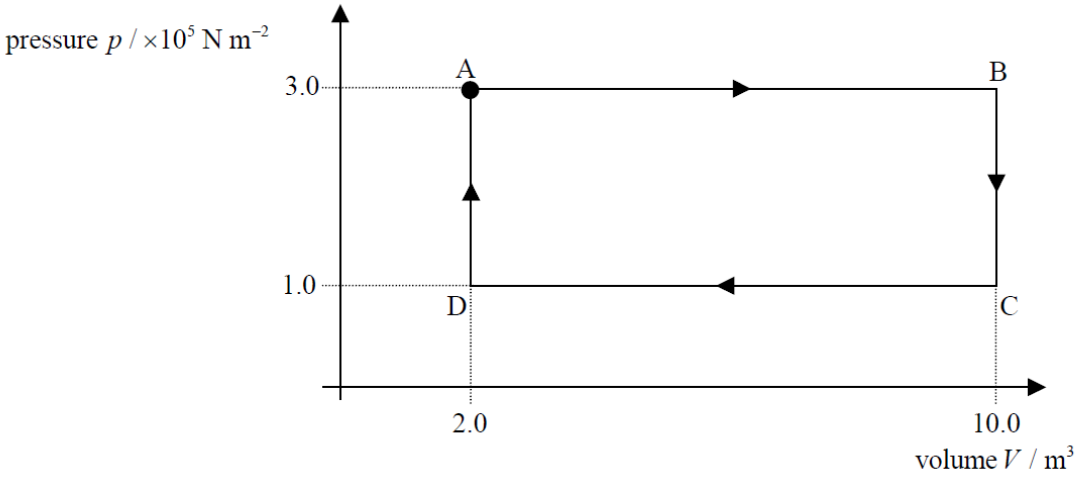
(ii) On the axes below draw a sketch graph to show the variation with volume V of the pressure p during this expansion. [3]



(iii) Use the sketch graph in (a)(ii) to **estimate** the work done by the gas during this process. [2]

(iv) Explain why less work would be done if the gas were to expand adiabatically from the same initial state to the same final volume. [1]

(b) In an idealized heat engine, a fixed mass of a gas undergoes various changes of temperature, pressure and volume. The *p*-*V* cycle (A→B→C→D→A) for these changes is shown in the diagram below



(i) Use the information from the graph to calculate the work done during **one** cycle. [2]

(ii) During one cycle, a total of 1.8 $\times 10^6$ J of thermal energy is ejected into a cold reservoir. Calculate the efficiency of this engine. [2]

(c) State, in terms of entropy change, the second law of thermodynamics. [1]

10. A source emits sound of frequency *f*. The source is moving towards a stationary observer at constant speed. The observer measures frequency of sound to be f'.

(a) Explain using a diagram ,why f' is greater than *f*. [3]

(b) The frequency f emitted by the source is 275 Hz. The source is moving at speed u ms^{-1} towards the stationary observer.The observed frequency f' of the sound is 293 Hz.The speed of sound in air is 330 ms^{-1}. Calculate the speed u of the source. [2]