

**HONG KONG ADVANCED LEVEL EXAMINATION
AL PHYSICS
1984 Structural Question**

1. Figure 1 shows the force-extension graph for a length of steel wire A. The wire obeys Hooke's law over the range of extensions considered.

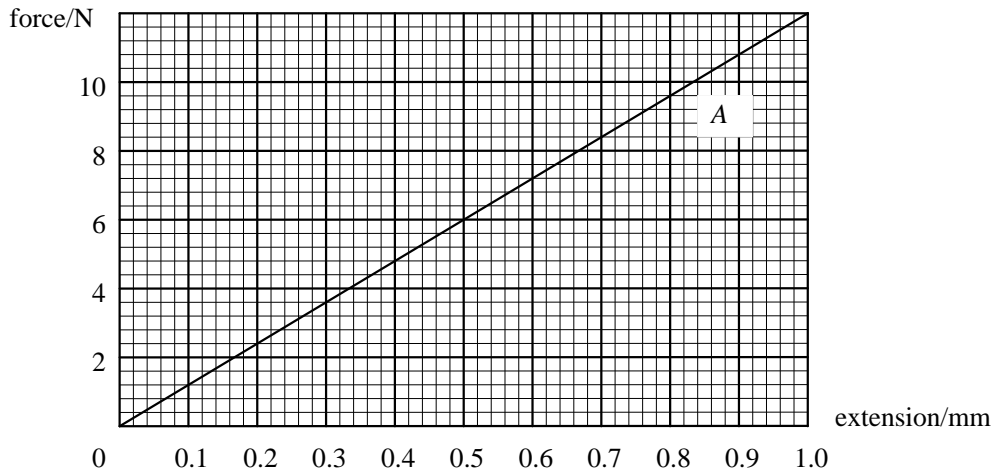


Figure 1

- (a) If the wire has a diameter of 0.40 mm and its unstretched length is 2.0 m, calculate the Young modulus of the steel.
- (b) A second wire *B* is made of the same steel. It has the same unstretched length as *A*, but twice the diameter. Draw accurately on the axes of Figure 1 the force-extension graph for this wire. Label your graph *B*.
- (c) A student discovers that for a given force within the range considered above, the elastic energy stored by wire *A* is four times greater than that stored by wire *B*. Use the two graphs, or some other theoretical argument, to explain this fact.
- (d) If the breaking stress of the steel is $5.0 \times 10^8 \text{ N/m}^2$, calculate the maximum force which can be applied longitudinally to wire *A*. (6 marks)

2.

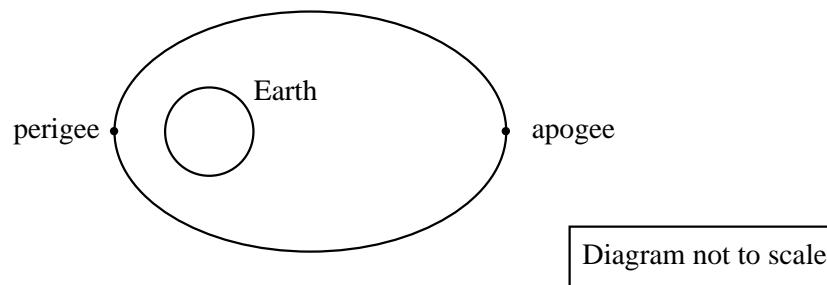
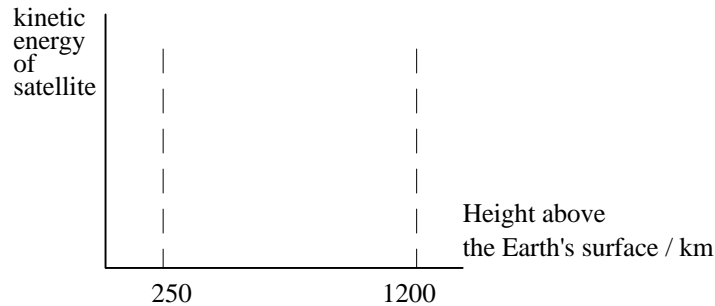


Figure 2

A satellite of mass 1 000 kg is describing an elliptical orbit around the Earth. The minimum height of the orbit above the Earth's surface is 250 km (at perigee) and the maximum height above the Earth's surface is 1 200 km (at apogee).

- (a) On the following diagram sketch the variation of the kinetic energy of the satellite with the height above the Earth's surface from perigee to apogee.



- (b) (i) If the velocities of the satellite at apogee and at perigee are v_a and v_p respectively, use the conservation of angular momentum equation to find v_a in terms of v_p .

- (ii) By considering the conservation of energy equation, hence determine the value of v_a .

(Gravitational constant	= $6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$,	
Mass of Earth	= $6 \times 10^{24} \text{ kg}$	
Radius of Earth	= $6.4 \times 10^6 \text{ m}$.)	(7 marks)

3. In Figure 3, the loudspeakers L_1 and L_2 placed 3 m apart are fed from a signal generator G , whose frequency is 680 Hz, so that they emit sound waves in phase. The speed of the sound waves is 340 m/s.

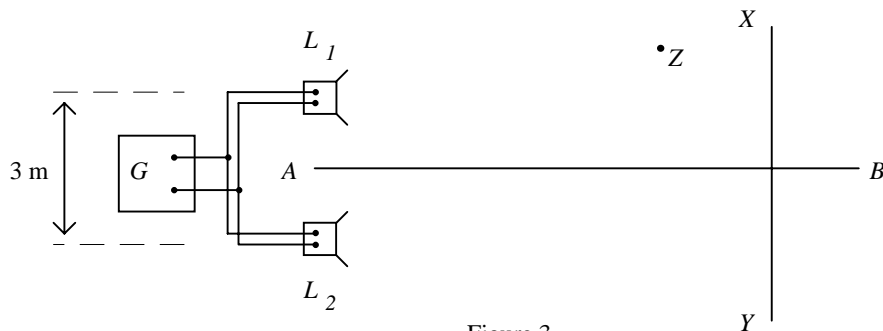


Figure 3

- (a) Describe the variation in the signal detected by a microphone when it moves slowly as follows:

- (i) along line AB , the perpendicular bisector of L_1L_2 .
- (ii) along line XY , parallel to L_1L_2 and about 20 m away from it.

- (b) Point Z in Figure 3 represents a point at which a minimum intensity sound is heard. When the loudspeaker L_2 is temporarily disconnected, a student finds that the intensity of the sound heard at Z increases. He finds this difficult to understand, as disconnecting L_2 presumably means that the total

output energy from the loudspeakers decreases. Write a short note explaining the result to the student and explaining why it does not conflict with the law of conservation of energy.

- (c) The loudspeaker L_2 is now reconnected, but with the connections to its terminals interchanged, so that it emits sound waves in antiphase with those from loudspeaker L_1 . Describe what effect, if any, this will have on the signal received by a microphone placed along XY compared with the arrangement in (a)(ii). (7 marks)

4. Figure 4 represents the energy levels of a hypothetical hydrogen-like atom:

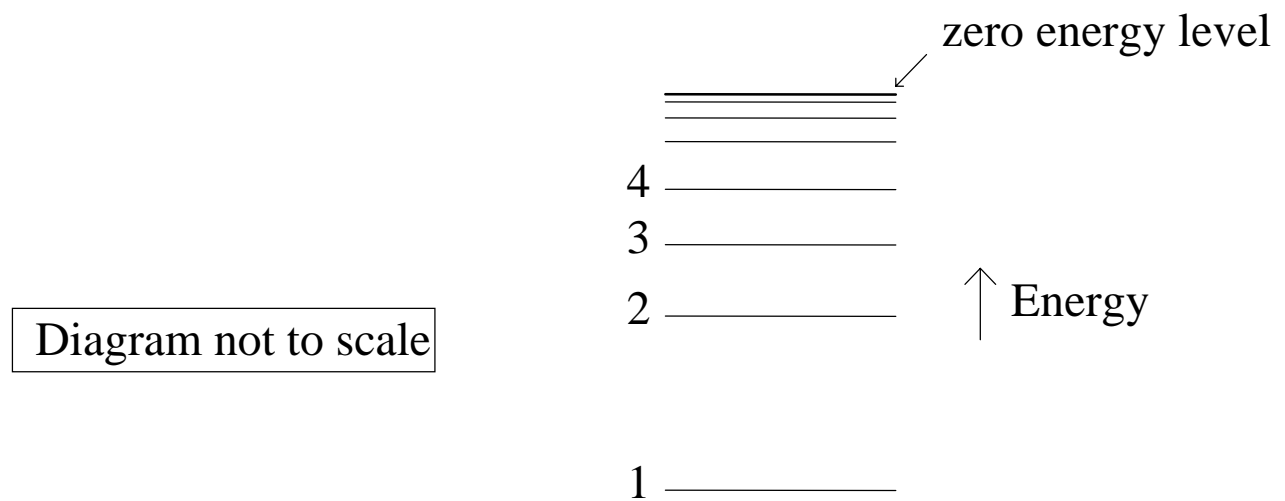


Figure 4

- (a) Mark on Figure 4 the ground state of the atom.
- (b) Briefly explain what is meant by 'the ground state of the atom'.
- (c) What is the significance of the zero energy level?
- (d) During the transition from level 3 to level 2 of the atom, photons of wavelength 600 nm are emitted. Calculate the ionisation potential for the atom.
- (e) Determine the energy (in eV) corresponding to levels 1, 2 and 3.

(Electron charge = 1.6×10^{-19} C
 Planck constant = 6.6×10^{-34} Js)

(9 marks)

5. In fine weather there is a uniform electric field near the Earth's surface of about 130 V/m, the Earth being negatively charged and the lower atmosphere being positive. The equipotentials are shown in Figure 5:

Height / m	Potential / V
5	650
4	520
3	390
2	260
1	130
0	0

Figure 5

- (a) Consider the case where a man is standing on open ground. Explain why the potential difference between his head and his feet is not in the region of 200 V as expected. Why doesn't he receive a shock?
- (b) Sketch, on Figure 6, the equipotentials in the vicinity of a clock tower on a fine day.

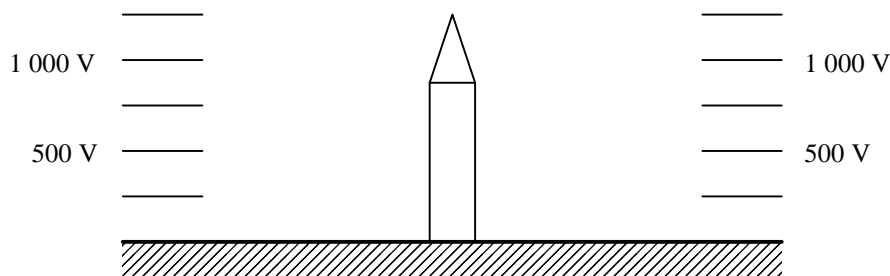


Figure 6

- (c) A thunder cloud with a large flat square base measuring 3 000 m \times 3 000 m passes over an area on level ground. Assuming the cloud carries a total charge of 40 C which is spread evenly over its base and is at a height of 0.5 km above the ground, estimate the potential of the cloud relative to the ground.

(Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12}$ F/m)

- (d) If the cloud in (c) discharges completely in a single lightning stroke lasting 10^{-3} s, calculate
- the mean discharge current, and
 - the energy released.

(9 marks)

6. A sinusoidal alternating voltage of 3.0 V r.m.s. and frequency 50 Hz is applied to the circuit shown in Figure 7, which consists essentially of a resistor R and capacitor C connected in series. The ammeter reads 0.3 A r.m.s. The two voltmeters V_1 and V_2 are designed to read r.m.s. voltages.

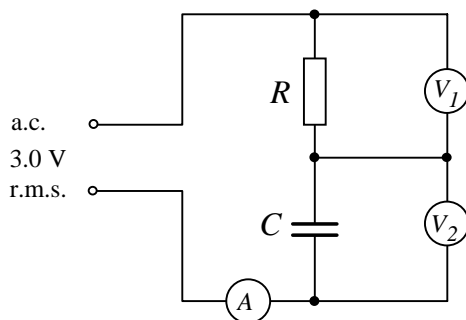
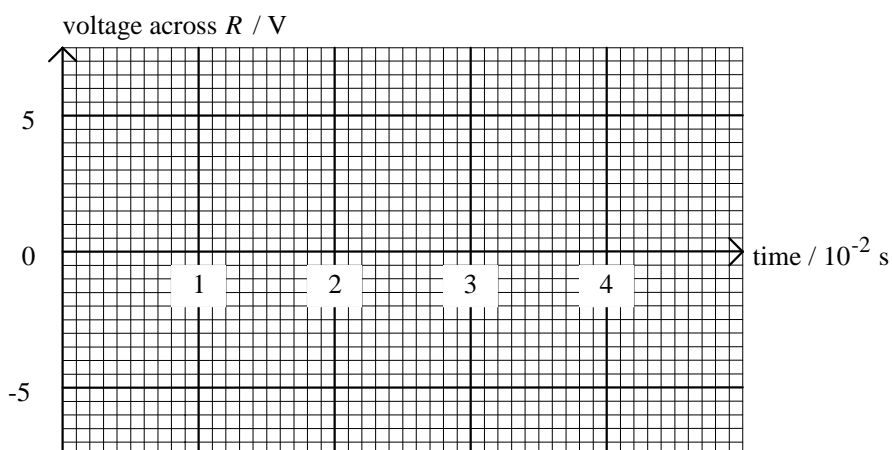
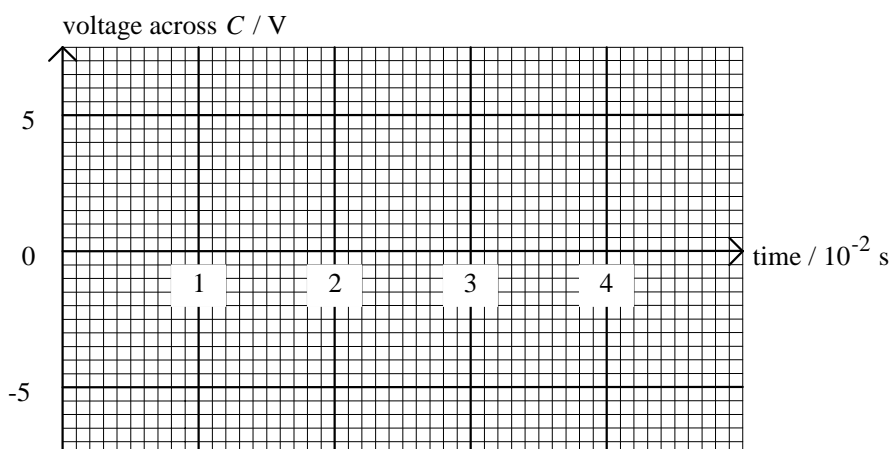


Figure 7

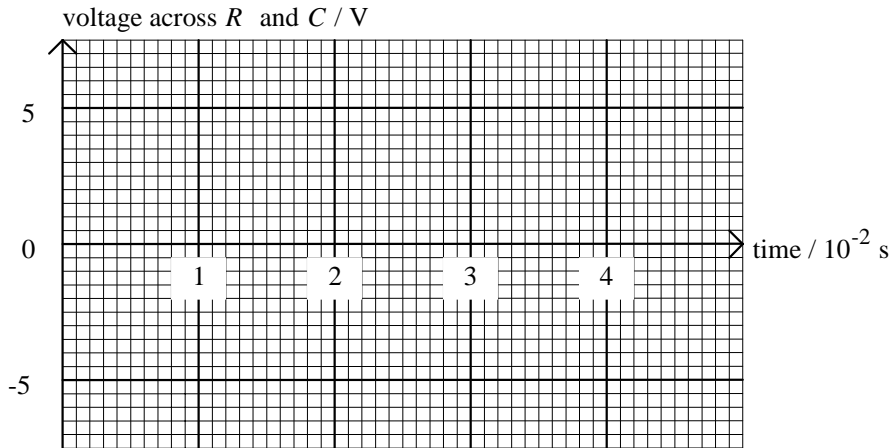
- (a) If the resistance of R is $8\ \Omega$, calculate the readings of the voltmeters V_1 and V_2 , and account for the fact that they do not add up to give 3.0 V.
- (b) On the spaces provided on the next page, and with the scales chosen as shown, sketch two cycles of
- (i) the time-variation of the voltage across R ,



- (ii) the corresponding time-variation of the voltage across C , and



- (iii) the corresponding time-variation of the voltage across R and C .



- (c) (i) Explain, without making any detailed calculations, how you would expect the reading of the ammeter to change when the frequency of the applied alternating voltage is increased if the amplitude is kept constant.
- (ii) What is the maximum r.m.s. value of the current in the circuit that could be obtained by adjusting the frequency of the voltage if the amplitude is kept constant? Explain briefly. (12 marks)

7.

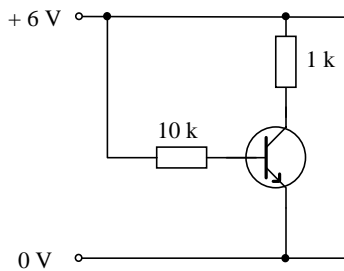


Figure 8

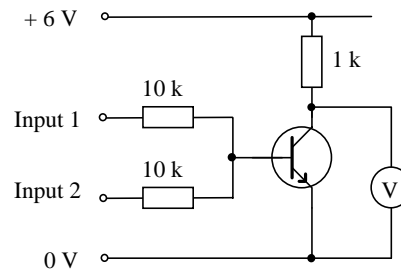


Figure 9

- (a) The circuit in Figure 8 shows an NPN silicon transistor and two resistors connected to a 6 V d.c. power supply. The current gain of the transistor is 100.
- (i) Calculate the value of the base current, stating clearly any assumptions you make.
- (ii) Calculate the value of the collector current. Give your reasoning.
- (iii) What is the potential difference between the collector and the emitter?
- (b) The same transistor is now used in the circuit in Figure 9. Inputs 1 and 2 can be connected to either +6 V d.c. or to 0 V. If an input is connected to +6 V d.c. it is said to be HIGH and if connected to 0 V it is said to be LOW. The output of the circuit is HIGH when the voltmeter reading is approximately 6 V and LOW when the reading is close to 0 V. Complete the following table for the circuit shown in Figure 9:

Input 1	Input 2	Output
LOW	LOW	
LOW	HIGH	
HIGH	LOW	
HIGH	HIGH	

- (c) A student is now given two light-dependent resistors (LDRs) and a small d.c. buzzer. The buzzer can be connected to the output of the circuit in Figure 9 and emits a loud noise when the output is high but no noise when it is low.

The student is asked to add the two LDRs and the buzzer to the circuit in Figure 9 to produce an alarm system. This system should emit a warning sound when the length of an object passing along a conveyor belt is greater than the distance l between the two LDRs (see Figure 10 below).

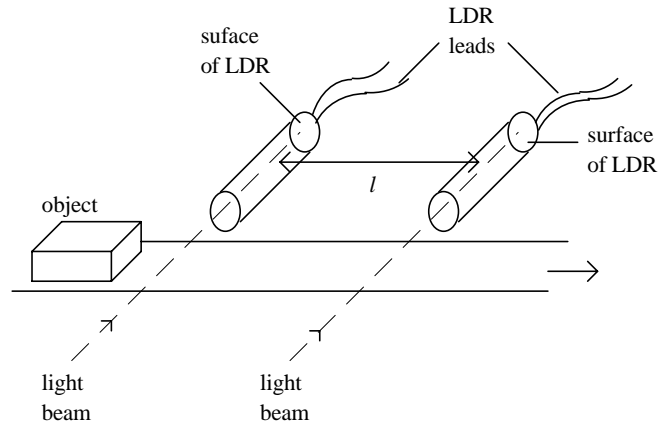


Figure 10

Each LDR is mounted in a cardboard tube and is illuminated by a light beam falling directly onto its surface. When illuminated the resistance of the LDRs is very low (a few ohms), but when the passing object interrupts a beam the resistance of the LDR in the path of the beam becomes very high (several megohms).

Complete the circuit diagram in Figure 11 below showing how the two LDRs should be connected to perform the necessary task. Use the symbol for an LDR shown in Figure 12. Briefly explain your reasoning.

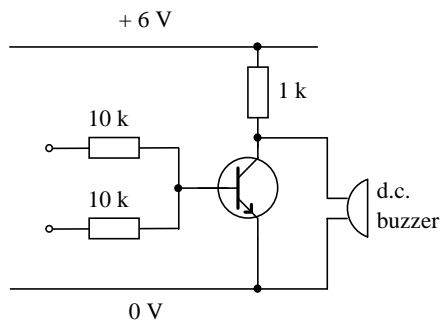


Figure 11

Complete this circuit by adding two LDRs

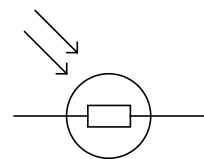


Figure 12

Use this symbol for an LDR

(10 marks)