HONG KONG ADVANCED LEVEL EXAMINATION
AL PHYSICS
1985 Structural Question

1.

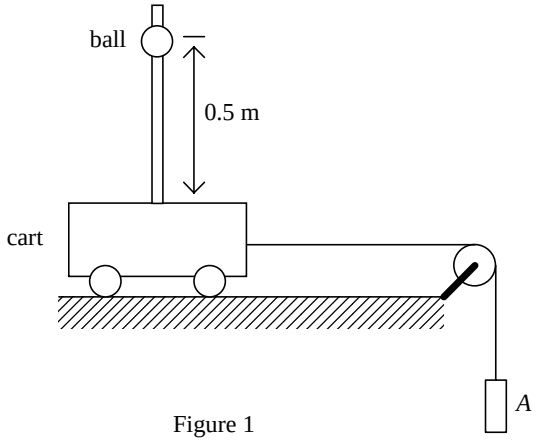


Figure 1

A cart is accelerated from rest across a horizontal table by the means shown in Figure 1. The cart has a vertical post at one side, on which a ball is held by an electromagnet at a height of 0.50 m above the cart. The mass of the cart and post is 3.0 kg and the mass of the ball is very small by comparison. The effective mass of *A*, after compensation for friction, is 1.0 kg and the mass of the string may be neglected. When the cart has travelled a distance of 1.0 m across the table, the ball is released.

(a) Draw a sketch graph and describe in words the path of the falling ball as seen by an observer who is stationary with respect to the table.

(b) Draw a sketch graph and describe in words the path of the falling ball as seen by an observer moving with the cart.

(c) Find the point on the flat surface of the cart where the ball lands.

(d) A camera fixed to the table records the ball's path from the time it is released until it lands. What horizontal distance would it record for the flight of the ball?

(10 marks)

2. (a) Two students have heard about the possibility of placing a communications satellite in an orbit such that it remains vertically above the same place on the surface of the Earth. One says the satellite must be so far away that it is not affected by the Earth's gravity. The other asks whether there is a communications satellite directly above Hong Kong. What would you say to each of them to help them understand such satellites?

(b) Considering the Earth to be a non-rotating sphere, Sir Issac Newton once argued that if a cannon-ball were fired horizontally at high enough speed from any point on the Earth, it would eventually return and strike the cannon from behind.

(i) Given that the speed of the cannon-ball remained constant, what would be the least time for it to arrive at the cannon again?

(The radius of the Earth may be taken to be 6.4×10^6 m and the acceleration due to gravity to be 10 m/s^2).

(ii) In reality, there are various reasons why the cannon-ball would not arrive at the cannon again. Give any three, with brief explanations. (10 marks)

3. A mixture of 0.20 mol of hydrogen (H_2) and 0.10 mol of oxygen (O_2) is held in a container at a pressure of 1.0×10^5 N/m^2. The gases are ignited by an electric spark and react to form 0.20 mol of water (H_2O, in the gaseous state). The energy released in the reaction is 300 kJ mol^{-1} of water. The initial temperature of the mixture is 300 K and the molar heat capacity at constant volume for water in the gaseous state may be taken to be 30 J mol^{-1} K^{-1}. The gases are assumed to obey the ideal gas law.

   (a) Assuming no heating or expansion of the container, what would be the temperature and pressure in the container after the reaction?

   (b) In practice, do these values appear realistic? Explain your answer. (7 marks)

4. (a) (i) A certain machine in a factory produces a 65 dB sound level when operated. Taking I_0 as the threshold of hearing, calculate the maximum number of machines which can be operated at the same time in the factory if the noise level is not permitted to exceed 72 dB.

   (ii) Suppose the ventilation system of the factory produces a background noise level of 4.5 dB. Would the total noise level exceed the noise limit of 72 dB when the maximum number of machines [as found in (i)] are operating in the factory? Explain your answer.

   (b) The following table shows some typical situations in everyday life. State the approximate noise-levels found in these situations.

Situation	Noise level / dB
(i) Quiet places such as libraries and hospital wards	
(ii) Normal traffic noise in Hong Kong	
(iii) Noise at a level which humans cannot bear	

   (c) Name one design feature used to lower the noise levels in buildings built near airports or busy highways. (8 marks)

5.

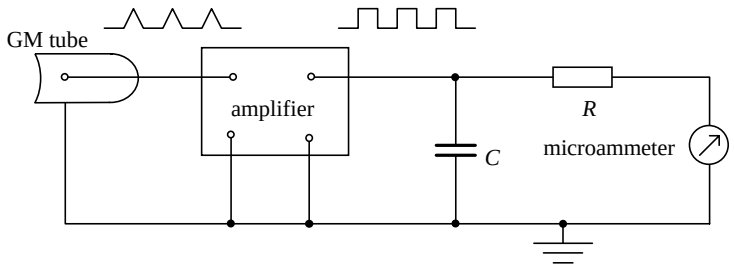


Figure 2

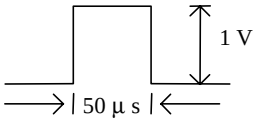


Figure 3

Figure 2 shows a simplified diagram of a ratemeter. The signal from the GM tube is fed into an amplifier. After shaping and amplification, the output signal is a square wave of amplitude 1 V and duration 50 μs (see Figure 3). Using an *RC* circuit, a corresponding current signal is observed in a microammeter.

When the GM tube is brought near a radioactive source, a steady pulse train of 100 pulses per second is produced and measured. The capacitance *C* and resistance *R* are of values 0.5 μF and 3 kΩ,

respectively. The output impedance of the amplifier is small during the charging of *C* but large during its discharging.

(a) (i) Calculate the time constant for the *RC* circuit.

(ii) A student claims that the capacitor is almost completely discharged during the interval between successive pulses. Justify this claim.

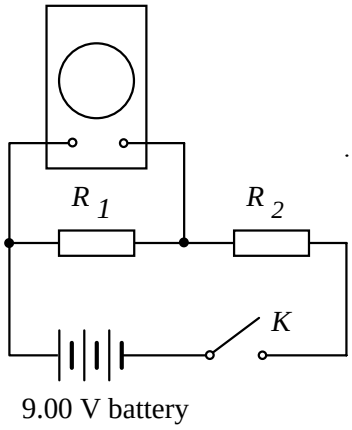
(b) Calculate the current through the microammeter.

(c) The original radioactive source is replaced by a weaker one such that, on average, only one pulse per second is produced by the GM tube. In order to have a steady reading on the microammeter, should the time constant of the *RC* circuit be increased or decreased? Explain your answer. (8 marks)

6. The input terminals of a C.R.O., on both the d.c. and a.c. settings, are thought to have

(1) a resistor *R* of resistance 1 - 10 MΩ, and
(2) a capacitor *C* of capacitance 10 - 100 pF

connected internally in parallel. From the following experiments it is intended to confirm the presence of these components and derive their values as accurately as possible.



Note :
R_1 and R_2 both have a resistance of 1.00 MΩ .

Figure 4

(a) The circuit used is shown in Figure 4. Using the d.c. setting of the C.R.O., the horizontal trace on the screen is observed to move to a level corresponding to 3.00 V when key *K* is closed. Determine the value of one of the components [either (1) or (2)], briefly explaining your reasoning.

(b) The 9.00 V d.c. supply is now replaced by an a.c. signal generator and the frequency and output adjusted to give a suitable waveform on the C.R.O. (using a.c. setting) so that the peak-to-peak voltage can be measured accurately. The signal generator is found to have an output of 7.07 V r.m.s. and a frequency of 3.20 MHz.

(i) Considering only the circuit consisting of the signal generator and the resistors R_1 and R_2 (i.e. ignoring any loading effect of the C.R.O.), write down the peak-to-peak voltage value of the waveform you might expect.

(ii) Now using the value you found in (a), give a more accurate estimate of the peak-to-peak voltage observed on the C.R.O.

(iii) However, the actual measured peak-to-peak voltage observed on the C.R.O. screen was only 20 mV. Hence, estimate the value of the other C.R.O. input component [(1) or (2)], briefly explaining your reasoning.

(9 marks)

7. In a hospital, radioactive waste produced by iodine-125 is stored in a special store-room before final disposal. Batches of waste with activity 100 μCi are deposited in the store-room regularly at 30 day intervals. It is found that the activity of the waste material in the store builds up gradually at first, but reaches a steady value later, as shown in Figure 5.

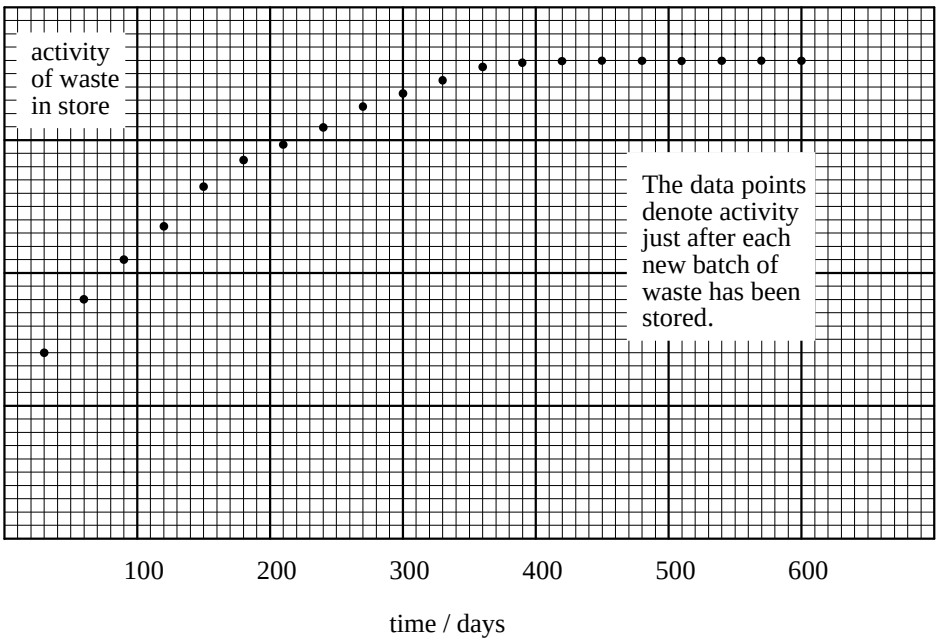


Figure 5

(a) (i) Explain why the activity of the waste material will not increase further even though new batches are deposited every 30 days.

(ii) Suppose the half-life of iodine-125 is 60 days, estimate the activity in the store-room when it reaches a steady value.

(b) After five years, this hospital stops using iodine-125. Before the waste material can be disposed of, it has to be kept until its activity falls to below 3 μCi. Calculate the storage period required.

(c) Iodine-125 nuclides emit low energy gamma-ray photons. Suggest two precautions that should be taken in handling this kind of radionuclide. (8 marks)

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