

HONG KONG ADVANCED LEVEL EXAMINATION
AL PHYSICS
1985 Essay Type Question

1. (a) Describe briefly the important details of an experimental arrangement to accurately determine, by direct measurement, the variation of the extension of a metal wire produced by an increasing applied force to one end when the other end is fixed.
- (b) Instead of using direct measurement, a student has the idea that he can increase the accuracy of the measurements of the extensions of the loaded wire by measuring the change of electrical resistance of the wire.
- (i) Assuming no change of cross-sectional area on stretching, show that theoretically, this is possible.
- (ii) Discuss the practicability of using this method with stainless steel wire of diameter 0.4 mm and resistivity $\sim 10^{-6} \Omega \text{ m}$, showing any necessary rough calculations.
- (No circuit details are expected.)
- (c) By considering the expected (qualitative) results for the loading of the wire in (a), and also those for the compression of a solid metal block, suggest a possible explanatory molecular model sketching the implied variations of
- (i) the potential energy and
- (ii) the force
- between the molecules as their separation varies. Explain the physical significance of the main features of these variations.
2. (a) State the principle of superposition for waves. Use this to explain the production of sound beats, and derive an expression for their frequency.
- (b) Use the principle of superposition to account for the observed phenomenon of interference, and state clearly the necessary physical conditions. Discuss the particular difficulties encountered in satisfying these conditions for normal light waves (not laser light), and state how these are overcome.
- (c) A rectangular wire frame is completely immersed in a soap solution and withdrawn carefully so that a soap film is stretched across the whole frame. Due to gravitational force and evaporation, the cross-section of the film will vary roughly with time as follows:

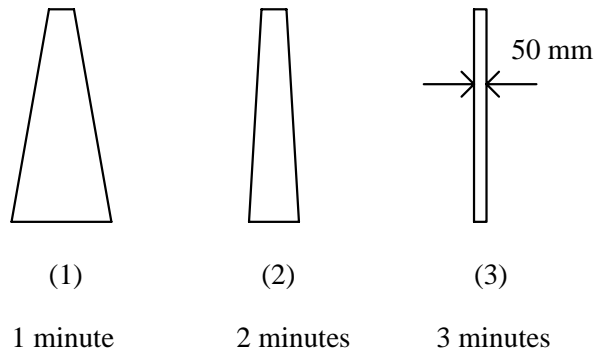


Figure 1

Give a qualitative account of what you would expect to observe during these 3 minutes if the film were illuminated by monochromatic light from behind the observer. Give brief explanations.

- (d) Suggest any one practical use for light interference (only brief details are required.)
3. (a) Faraday's laws of electromagnetic induction may be summarised by the equation $E = -\frac{d\phi}{dt}$.
Explain the physical meaning of this equation, using a coil of wire as an example.
- (b) Give brief details of one useful practical example of electromagnetic induction in a coil which involves
- movement of the coil;
 - no movement of the coil.
- (c) Explain the effect of electromagnetic induction on
- the switching-off of a current supply to an electromagnet; and
 - the heating of a transformer core.
- In each case, give a diagram showing the actual instantaneous direction of the induced e.m.f.
- (d) Briefly explain suitable precautions which can be taken to minimise the detrimental effects produced by the electromagnetic induction in (c) (i) and (c) (ii).

4. (a) Draw a diagram of a circuit you would use to determine the input-output d.c. voltage characteristic of an NPN transistor operating in the common emitter configuration. Give the approximate values of the resistances used in your circuit, explaining why they are used.
- (b) Draw a graph of a typical input-output voltage characteristic. With reference to this characteristic, explain the use of such a transistor for
- voltage amplification, and
 - switching.
- (c) Show how the simple transistor switching circuit can be used in
- a NOR gate, and
 - an OR gate.

For each of these configurations give a truth table, and explain the logic of the possible operations.

5. (a)

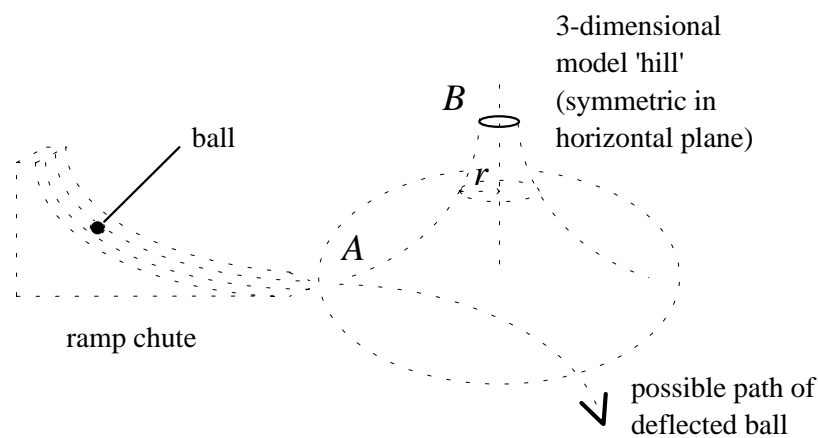


Figure 2

In a gravitational analogue simulation of α -particle scattering by a thin metal sheet, balls are allowed to roll down a ramp chute on to a model 'hill' where they experience deflection, as in Figure 2.

- Explain the necessary variation of the profile (AB) of the 'hill' with the radius (r) of the horizontal cross-sections.
- Using this experimental arrangement how would you simulate the scattering of α -particles through different angles of deflection? Comment on the expected results.

- (iii) Further explain how you would simulate the scattering of α -particles of various energies and state the expected results (qualitatively).
- (iv) Using this analogy, demonstrate how an upper limit to the size of a nucleus can be estimated.
- (v) Suggest possible practical inadequacies of this gravitational analogue.
- (b) Briefly describe the experimental evidence which convinced Chadwick that neutrons are neutral particles, similar in mass to protons.

6. (a)

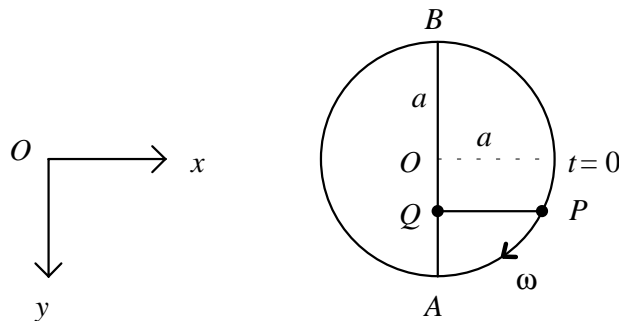


Figure 3

A point P moves in a circular path, around O as centre, with a constant angular velocity ω .

- (i) Show that point Q , the projection of P on the diameter AB , moves with an acceleration towards O and that the magnitude of the acceleration is proportional to the displacement of Q from O . (O is the starting position for time $t = 0$.)
- (ii) Write down mathematical expressions for
- (1) the displacement of Q from O ,
 - (2) the velocity of Q ,
 - (3) the acceleration of Q ,
- at any subsequent time t .
- (iii) Hence, using the same time axis, plot the variations of (1), (2) and (3) with time during one complete cycle of motion of Q .

(b) If Q represents the location of a mass m suspended from a vertical hanging, light spiral spring which undergoes oscillations in a vertical plane, write down mathematical expressions for the variation with time of

- (i) the kinetic energy, and
- (ii) the potential energy

of the system. (The mass of the spring should be ignored.)

Plot the above time variations on a graph directly underneath the previous graph, using a similar scale for the time axis.

(c) An additional S.H.M., acting along the x -direction, is now superimposed upon the original motion of Q , having the same amplitude a and angular velocity ω .

- (i) Derive the equations of the resultant paths of motion of Q for the following conditions:
 - (1) the phase difference between the two motions is zero,
 - (2) the phase difference is $\pi/2$,
 - (3) the phase difference is zero, but the angular velocity of the x -direction motion has increased to 2ω .
- (iii) For each condition, sketch the path traversed by Q , and indicate the direction of motion.

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