

1169T2/2001

Question 1 (marks)

- a) Write the equations of two travelling waves, $y_1(x,t)$ and $y_2(x,t)$, which, when they superpose, produce a standing wave.
State the amplitude, wavelength and frequency of the resultant standing wave in terms of constants in your equations.
- b) A steel guitar string has a diameter of 0.33 mm, a vibrating length of 650 mm and a density of $5,600 \text{ kg.m}^{-3}$.
- Calculate the tension required to tune it so that its fundamental frequency of vibration is 330 Hz.
 - State some of the other frequencies can it vibrate, and illustrate the modes of vibration with a sketch.

Question 2 (marks)

- a) A man is whistling with a steady frequency f_m of 1000 Hz. He is walking directly towards a wall at speed $v_m = 5 \text{ km.hr}^{-1}$. At what frequency would he expect to hear beats, between the sound he is whistling and the echo from the wall? (The speed of sound is 345 m.s^{-1})
- b) A particular ear-plug reduces the sound level at the ear by 23 dB. Determine
- By what factor does it reduce the sound power transmitted to the ear?
 - By what factor does it reduce the sound pressure at the ear?
- c) The speed of sound in water is faster than the speed of sound in air. In one or two sentences, and with one equation, explain why this is so.

Question 3 (marks)

- a)
 - What is a diffraction grating? (One clear sentence will do.)
 - Light with a particular wavelength λ strikes a diffraction grating at normal incidence. Draw a sketch of the intensity I as function of $\sin \theta$, the sin of the angle between the normal and the light leaving the grating
 - With the aid of a sketch, derive an expression for the angle θ_1 , the angle of the first maximum in I on either side of the central maximum at $\theta = 0$.
- b)
 - With the aid of a diagram, explain how an anti-reflective coating on a lens works.
 - Estimate the thickness of the coating if the coating material has a refractive index of 1.4 and the antireflective property is optimised for light of wavelength $\lambda = 550 \text{ nm}$ in air.

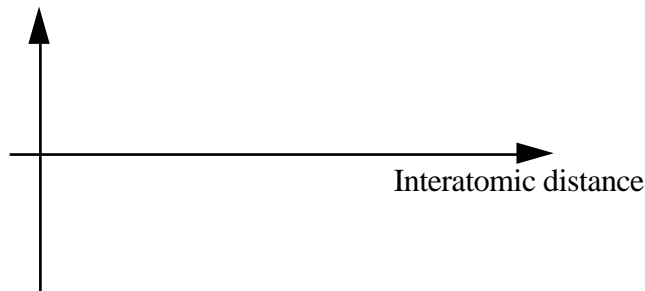
Question 4 (marks)

- a) A tank has a volume V_0 at a reference temperature T_0 , and is made of a material with linear coefficient of thermal expansion α_m . At temperature T_0 , it is completely filled by a liquid with volumetric coefficient of thermal expansion β_l . Derive an expression for the volume ΔV that overflows from the tank at a temperature T .
- b) Using the equation of state for an ideal gas, derive an expression for the density ρ of an ideal gas in terms of the pressure P , temperature T , molecular mass m and constants.

Question 5 (12 marks)

- a) Use these axes to sketch your answers to the following questions. If you spoil this copy, Use the copy of these axes on the opposite page.

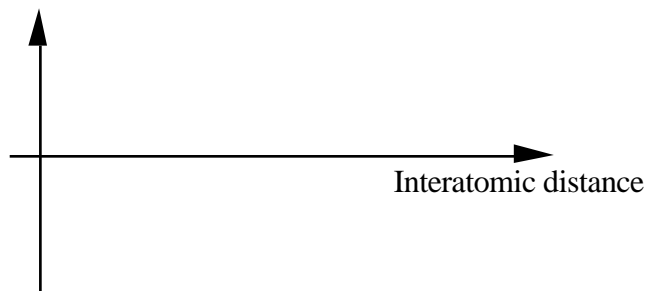
Attractive and repulsive forces



- i) On the upper graph, sketch the interatomic attractive force as a function of interatomic distance
- ii) Also on the upper graph, sketch the interatomic repulsive force as a function of interatomic distance.

Indicate clearly which is which.

Total interatomic force



- iii) On the lower graph, and to the same scale, sketch the total interatomic force as a function of interatomic distance.
- iv) On the lower graph, sketch the behaviour corresponding to Hooke's law (*ie* behaviour with a constant Young's modulus).

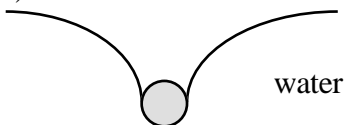
Indicate clearly which is which.

- b) i) Define stress
 ii) Define longitudinal strain
 iii) Sketch a stress-strain relation for a material for which an elastic modulus may be defined. On your sketch, indicate a feature related to the elastic modulus. **Also** on your sketch, indicate hysteresis (or history dependent behaviour).

Question 6 (marks)

- a) With the aid of simple sketch, explain why molecules at the surface of a liquid have a higher energy than those in the interior of the liquid.

b)



A spherical bead, with density ρ , is supported at the surface of water. What is the diameter of the largest bead that can be thus supported, with the total force due to surface tension equal to the weight of the object? Express your answer in terms of the diameter of the bead and the surface tension γ_w of water. (You need not consider the effects of buoyancy.)