1169T2, 2000

Question 1 (11 marks)

a) Write the equations for two travelling waves which together in superposition could produce a standing wave.

b) In a building designed by a prominent Sydney architect, rigging cables are used as structural elements. One such cable is 8 m long, 8 mm in diameter, and subject to a tension of 7.0 kN under a particular set of load and wind conditions. The cable is made of an alloy with a density of 5,600 $kg.m^{-3}$.

i) Estimate the first 5 resonant frequencies of the cable.

ii) Briefly explain how the phenomenon of resonance could be important in this instance.

Question 2 (11 marks)

a) A helicopter is stationary and high in still air. It radiates a sound power of 80 W uniformly in all directions.

i) Determine the sound intensity at a distance of 100 m from the helicopter. Show your working.

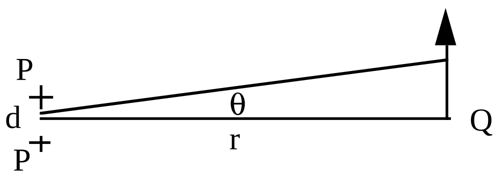
ii) Determine the sound intensity level (in decibels) at a distance of 100 m from the helicopter.

b) In still air, how fast must a moving sound source travel towards a stationary observer if the stationary observer measures the frequency of the sound to be 33% higher than the frequency emitted by the source? (Speed of sound = 340 ms^{-1}.)

c) Calculate, showing your working, the ratio v_{He}/v_{Ar}, where v_{He} is the speed of sound in helium, and v_{Ar} is the speed of sound in argon at the same pressure. (Both are monotonic gases and their atomic masses are 4.0 and 40 $kg.kmol^{-1}$, respectively.)

Question 3 (13 marks)

a)



Two radio antennæ, separated by distance d, radiate the same signal, with the wavelength λ (<<d) and same power P. They are in phase. At a distance r away (r >>d), the intensity I is measured as a function of θ.

i) Sketch the dependence of the measured intensity as a function of θ, i.e. $I(\theta)$.

ii) At what value of θ does the first minimum occur?

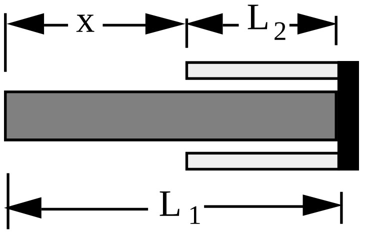
iii) When one of the antennæ is turned off, what is the change in the value of the intensity I at the point Q (i.e. at $\theta = 0$)? Explain how you reached your answer.

b) i) With the aid of a diagram, explain how an anti-reflective coating on a lens works.

ii) 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 $\lambda = 550$ nm in air.

Question 4 (5 marks)

a)

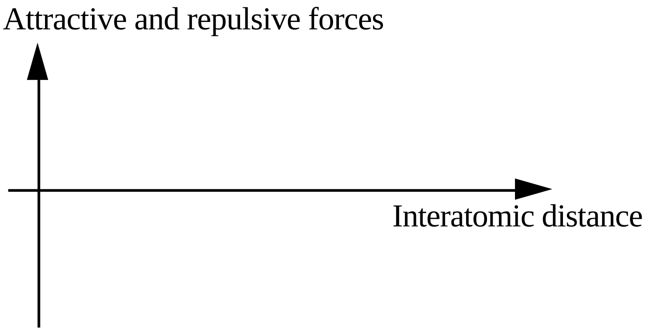


The figure shows a low expansion mounting, designed so that the distance x has minimal change with temperature. The inner and outer shafts are made of materials with linear thermal expansivity coefficients α_1 and α_2, respectively.

Derive an equation that relates the two lengths L_1 and L_2 to the coefficients α_1 and α_2.

Question 5 (12 marks)

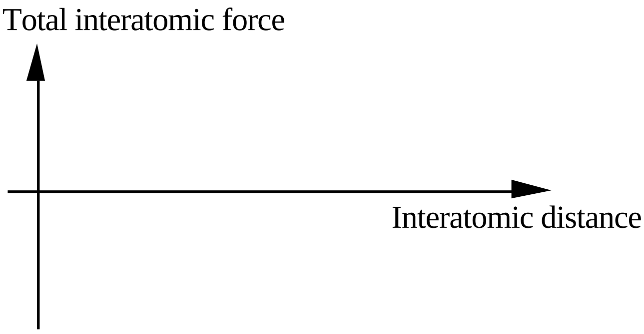
a) Use these axes to sketch your answers to the following questions. If you spoil this copy, Use the copy of these axes on the opposite page.



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.



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 of Hooke's law (*ie* behaviour with a constant Young's modulus).

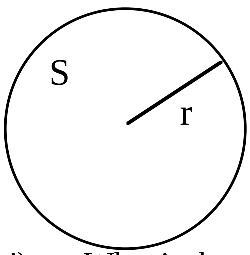
Indicate clearly which is which.

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).

Q6 (8 marks)



A bubble of radius r, is surrounded by a pure liquid. The interface has a surface tension S. The vapour in the bubble has negligible pressure, but the liquid has a pressure P.

i) What is the energy associated with the interface (surface) between the bubble and the liquid?

ii) What is the work done against the pressure in the fluid to make a bubble of this size in the liquid?

iii) By considering the work done in expanding the bubble radius by dr, or otherwise, derive an expression for the critical radius for cavitation.

iv) When a crack forms in the edge of a plate, maintenance workers may drill a hole in the plate at or near the end of the crack. Explain how this could work.