

Vibrations & Waves Classwork 3 (Monday 31 January 2005)

DJ k-T Selecta is hosting a party for the *Imperial Massive* crew in the Union. Deciding to do a drum 'n' bass set, she is very unimpressed with the lack of bass in the hired sound system. She decides to boost the low frequency range and truly get the party (and most of SW7) moving by constructing her own mega-woofer speaker with an output at a frequency of between 20 and 1 Hz. She constructs a very large carbon-fibre disk suspended by some springs. In the centre of the disk is a magnet. The magnet sits inside a wire coil fixed to a support. The disk can then be driven by an electric current through the coil. The mass of disk & magnet $m = 1$ kg. Using the support springs she can adjust the spring constant s . She can also adjust the mechanical resistance r , mostly due to the volume of air shifted, by varying the disk diameter.

[Coupled Oscillations, Lecture 7]

k-T first decides to tune the frequency of her mega-woofer by coupling it by a spring of spring constant S_c to a large simple pendulum of length L and mass m .

- i) What values of L and s should she use to tune both her pendulum and mega-woofer to the same frequency $f = 1$ Hz? (take $g = 10\text{ms}^{-2}$).
- ii) What is the angular frequency ω_1 of the in-phase normal mode of pendulum and mega-woofer?
- iii) The anti-phase normal mode of pendulum and mega-woofer has an angular frequency of:

$$\omega_2 = \sqrt{\left(\omega_0^2 + \frac{2S_c}{m}\right)}$$

If $\omega_2 = 7$ rad/s, what is S_c ?

[Forced SHM, Lecture 6-7]

She decides she wants to maximise her *power output* at $f = 10\text{Hz}$.

- iv) What spring constant s does she now need?
- v) k-T wants her speaker to respond to frequencies between 20 and 1 Hz. What mechanical resistance r does she need?

[Waves, Lecture 8]

She connects her speaker to her power amp and switches it on. She tests her speaker with a frequency $f = 10$ Hz.

- vi) What sort of waves are produced - transverse or longitudinal? What is their wavelength λ in air (phase velocity $v = 344$ ms^{-1})? What is k ?
- vii) The maximum displacement of the piston is 0.05 m. Write down an equation for the waves (assume $\phi = 0$ and that the wave is real).
- viii) It reaches 30°C inside the Union. She decides to move the party outside where its 10°C. Sound waves in air obey:

$$v = \sqrt{B/\rho} \propto \sqrt{T}$$

where B is the bulk modulus of air, ρ the density and T the temperature in K (Young & Freedman, p. 598-601). How will temperature affect the wavelength?

- ix) When she switches the system on, how soon before the residents of Buckingham Palace 1 km away can move to the groove?