TAP 307- 9: Car suspension

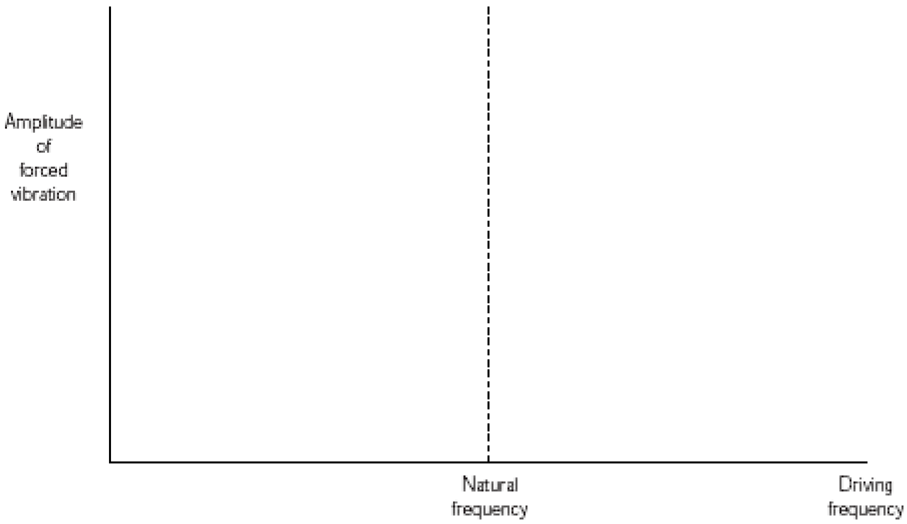
The axles and wheels of a car are attached to the car body by a spring suspension system in order to give the passengers a smooth ride. As the car travels over bumps in the road, the wheels follow the road surface up and down, but the much more massive car body moves more-or-less horizontally. The motion of the car wheel and axle therefore approximates to that of an oscillating mass suspended by a spring from a fixed support (the car body).

1.

(a) If you sit over the wheel-arch of a car, your weight depresses the suspension. Assuming that the suspension obeys Hooke's law, estimate its stiffness, k. Show any other quantities you estimate or calculate in order to arrive at a value for k.

(b) If the spring suspension from (a) is used to suspend a wheel and axle whose combined effective mass is m = 100kg, what would be the approximate natural frequency of oscillation of the wheel-plus-axle?

(c) The car wheel-plus-axle system is forced to oscillate as the car goes along a bumpy road. If the bumps become closer together, or the car travels faster, the frequency of these oscillations increases. On the axes below, sketch graphs to show how the amplitude of the oscillations changes as the driving frequency changes in the case where



(i) there is little damping of the suspension and

(ii) when the suspension is heavily damped.

(d) Comment on whether the suspension system of a car should lightly or heavily damped if the aim is to give passengers a smooth ride.

Practical advice

This question provides a similar tangible and interesting context in which to talk about resonance. It does however have a different style and wording.

Answers and worked solutions

1

(a) Depression x ≈ 5 cm (allow 2 – 10cm)

Person's mass ≈ 60 kg (50–90 kg), weight W ≈ 600N

k = W/x = 600N / (5 x 10^{-2}m) ≈ 1 x 10^{4}Nm^{-1}

(b) Wheel experiences restoring force, magnitude *F* = kx and acceleration *a* = -kx/m

Identify SHM with ω^2 = k/m

$$f = \frac{1}{T} = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \approx \frac{1}{2\pi}\sqrt{\frac{1x10^4}{100}} = \frac{10}{2\pi}$$ = 1.6 Hz (accept 1 - 2Hz)

External reference

This activity is taken from Salters Horners Advanced Physics, section BLD, additional Sheets 11 and 12