inkPhysics

QUESTION WORKBOOK

Forced vibrations and resonance

Periodic motion · Year 13

AQA 3.6.1.4 · CIE 17.3.3 · OCR A 5.3.3(a), 5.3.3(b)(i), 5.3.3(c), 5.3.3(d), 5.3.3(e)

18 questions · 54 marks

NAVY SCREEN EDITION

SECTION A · Warm-up

A1 Distinguish between free vibrations and forced vibrations. [2]

A2 Define resonance. [2]

A3 State the condition for resonance to occur. [2]

A4 Several pendulums of different lengths hang from the same taut horizontal cord. A driver pendulum of length 0.60 m is set swinging. State which of the other pendulums oscillates with the largest amplitude, and explain why. [2]

A5 A tuning fork marked 512 Hz is struck and held near a second, identical, unstruck fork. The second fork begins to sound. Explain why. [2]

SECTION B · Standard

B1 A mass–spring system has a spring constant of 100 N m^{-1} and a mass of 0.25 kg. Calculate its natural frequency, and state the driving frequency that would cause resonance. [3]

B2 Sketch and describe how the amplitude of a driven system varies with driving frequency. [3]

B3 A simple pendulum of length 0.50 m is used as a driven oscillator (g = 9.81 m s^{-2}). Calculate its natural frequency, and state the driving frequency needed for resonance. [3]

B4 Describe how increasing the amount of damping changes the resonance peak. [3]

B5 The wing mirror of a van vibrates violently when the engine runs at 1500 revolutions per minute, but is nearly steady at other engine speeds. Determine the natural frequency of the mirror on its mounting, and explain what happens to the vibration when the engine speed rises to 3000 revolutions per minute. [3]

B6 A string is stretched between two fixed points 0.80 m apart. Waves travel along the string at 40 m s^{-1}. Calculate the fundamental frequency of the string, and state what is observed when a vibration generator drives the string at this frequency. [3]

B7 A student drives a mass-spring system at a range of frequencies and records the amplitude. Driving frequency/Hz: 2.0, 2.25, 2.5, 2.75, 3.0. Amplitude/mm: 4, 9, 23, 8, 5. State the approximate natural frequency of the system, and explain why the amplitudes at 2.0 Hz and 3.0 Hz are much smaller than the maximum. [3]

SECTION C · Stretch

C1 A system has a natural frequency of 50 Hz. Describe what happens to its amplitude as the driving frequency is slowly increased from well below 50 Hz to well above it. [4]

C2 Explain why resonance can be dangerous for a structure such as a bridge, and state one way engineers reduce the risk. [4]

C3 Give one useful example and one problematic example of resonance. [2]

C4 A car bounces on its suspension with a natural frequency of 1.3 Hz. It is driven along a road with regularly spaced ridges 12 m apart, where the speed limit is 13.4 m s^{-1}. Deduce whether the car can experience resonance without breaking the speed limit. [4]

C5 Describe how the phase of a driven oscillator, relative to the driver, changes as the driving frequency increases from well below the natural frequency to well above it. [3]

C6 A thin metal panel on a machine rattles loudly, but only when the machine's motor runs within a narrow band of speeds. Explain fully why this happens, and describe two changes the designer could make to reduce the rattling. Use the ideas of forced vibrations, resonance and damping in your answer. [6]