Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Two identical waves travelling in opposite directions superpose; a node is a point of zero displacement where the two always cancel.

2.2 Same side of a node: in phase, 0°; opposite sides: antiphase, 180°.

2.3 $f_1 = v/2L = 160/1.6 = 100$ Hz; $f_2 = 200$ Hz.

2.4 Any two of: the maximum amplitude falls; the peak broadens; the resonant frequency shifts slightly below the natural frequency.

3.1 $f_1 = v/4L = 340/1.36 = 250$ Hz; the next harmonic is the third, $f_3 = 750$ Hz; a node must exist at the closed end and an antinode at the open end, so only an odd number of quarter-wavelengths fits – the second harmonic cannot meet both conditions.

3.2 A displacement node at each fixed end; a standing wave must fit a whole number of half-wavelengths between the nodes, $\lambda_n = 2L/n$, so only those wavelengths reinforce after reflection – all others destructively interfere away.

3.3 As bump frequency approaches 1.5 Hz the amplitude grows sharply – resonance; at higher driving frequencies the amplitude falls again; shock absorbers damp the oscillation, lowering the resonant peak and broadening it, so the car cannot build up a large amplitude at any speed.

3.4 Open–open: $f_1 = v/2L = 340/1.0 = 340$ Hz; closed–open: $f_1 = v/4L = 340/2.0 = 170$ Hz; ratio 2:1 – an octave apart (stated on either line).