

2019B F=ma Exam: Problem 23

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The train undergoes simple harmonic motion in the vertical direction. It takes the train one period

$$T = \frac{d}{v}$$

to travel through one cycle of the track. Thus, the angular frequency is

$$\omega = \frac{2\pi}{T} = \frac{2\pi v}{d}$$

Recall for simple harmonic motion, the maximum acceleration is

$$a_{max} = \omega^2 A$$

where A is the amplitude. We have

$$a_{max} = \left(\frac{2\pi v}{d}\right)^2 h \leq a_c$$

Hence,

$$h \leq a_c \left(\frac{d}{2\pi v}\right)^2 = (0.1 \text{ m/s}^2) \left[\frac{1 \text{ km}}{2\pi(360 \text{ km/hr})}\right]^2 = 25 \text{ cm}$$