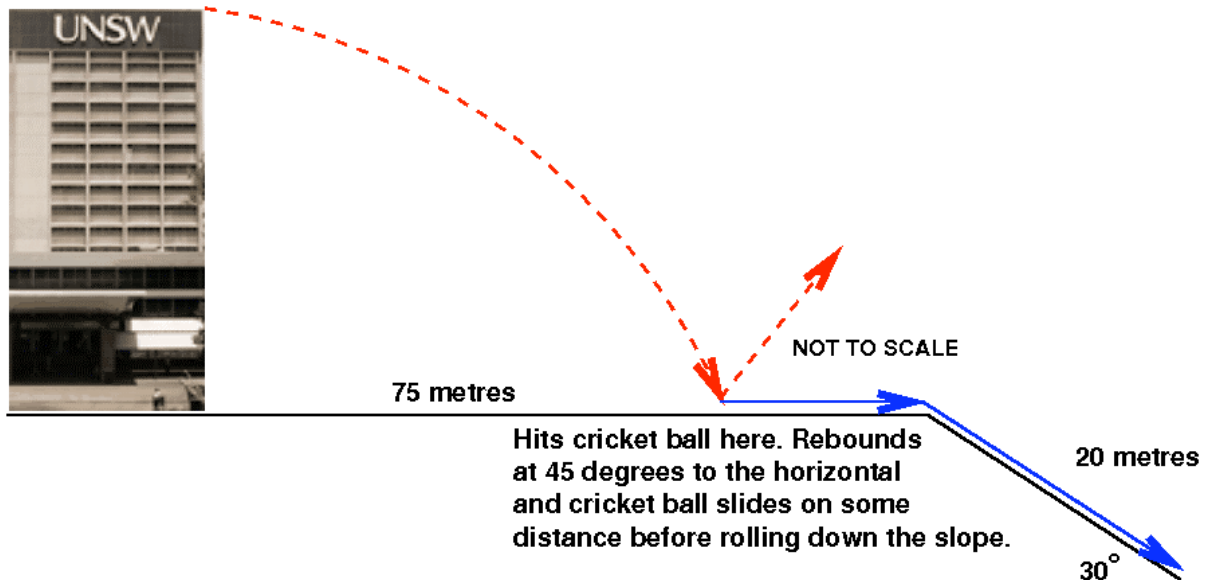


Question 1. [Marks 18]

- (a) A basket ball of 600 gramme mass is kicked horizontally from the edge of a building and hits a cricket ball, located at 75 metres from the base of the building 2.5 seconds later. Stating any assumptions you use, calculate:

Basket ball is kicked



- (i). The height of the building.
(ii). The velocity at which the basket ball hits the cricket ball.
- (b) The basket ball impacts with a stationary cricket ball, of 160 gramme mass. The basket ball rebounds at an angle of 45° to the horizontal, as shown in the figure. Upon the impact, the cricket ball moves off horizontally with no vertical component. Assuming the balls do not spin and that no momentum is imparted to the Earth, calculate:
- (i). The speed of the basket ball immediately after impact.
(ii). The speed of the cricket ball immediately after impact.
- (c) Due to friction, the cricket ball slows down to rest by time it has slid to the edge of the slope, 10 seconds later.
- (i). What is the coefficient of kinetic friction of the surface?
(ii). What is the work done by the friction in this time?

Question 3 [15 marks]

- (a) A water heater is operated by solar power. If the solar collector has an area of 6.00 m^2 , and the intensity delivered by sunlight is 550 W/m^2 , how long does it take to increase the temperature of 1.00 m^3 of water from 20.0°C to 60.0°C ?
- (b) In a 30.0 s interval, 500 hailstones strike a glass window of area 0.600 m^2 at an angle of 45.0° to the window surface. Each hailstone has a mass of 5.00 g and moves with a speed of 8.00 m/s . Assuming the collisions are elastic, find the average force and pressure on the window.

Question 4 [12 marks]

A 2.00 kg object is attached to a spring and placed on a horizontal, smooth surface. A horizontal force of 20.0 N is required to hold the object at rest when it is pulled 0.200 m from its equilibrium position (the origin of the x axis). The object is now released from rest with an initial position of $x_i = 0.200 \text{ m}$, and it subsequently undergoes simple harmonic oscillations.

- (a) Find the force constant of the spring.
 (b) Find the frequency of the oscillations.
 (c) Find the maximum speed of the object. Where does this maximum speed occur?
 (d) Find the maximum acceleration of the object. Where does it occur?
 (e) Find the speed of the object when its position is equal to one third of the maximum value.
 (f) Find the acceleration of the object when its position is equal to one third of the maximum value.

Question 5 [18 marks]

- (a) A violin string has a length of 0.350 m and is tuned to concert G, with $f_G = 392 \text{ Hz}$. Where must the violinist place her finger to play concert A, with $f_A = 440 \text{ Hz}$?
- (b) Two loudspeakers are placed on a wall 2.00 m apart. A listener stands 3.00 m from the wall directly in front of one of the speakers. A single oscillator is driving the speakers at a frequency of 300 Hz .
- (i) What is the phase difference between the two waves when they reach the observer?
- (ii) What is the frequency closest to 300 Hz to which the oscillator may be adjusted such that the observer hears minimal sound?

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Question 6 [15 marks]

A car travels clockwise at constant speed around a circular track, as shown below. It emits a constant sound at a frequency of ν_0 kHz. An observer, sitting at position P, hears the pitch of this sound rise and fall as the car goes around the track.

We wish to see *qualitatively* how the frequency varies, and a comparison of the maximum and minimum observed frequencies observed for the various cases.

- Plot a graph of frequency (plotted vertically) versus time (plotted horizontally) showing the frequency observed by a person sitting at position f as the car makes one full circuit of the track. Mark on the graph the times at which the car is at positions a, b, c and d.
- On the same graph, plot the frequency observed by a person sitting on the track at position c.
- On the same graph, plot the frequency observed by a person sitting at position e.
- On the same graph, plot the frequency observed by a person sitting at position O (the centre of the circle).

