Unit 25 · Recent Trends in Physics

HARDER PRACTICE QUESTIONS

Full marks 31

Write your answers on separate paper. Show your working. Use $E_1/E_2 = 10^{1.5(M_1 - M_2)}$ for energies, and 10 times the wave height for each step of magnitude.

1 Spot the error [3]

Find the mistake in the working and correct it.

Asked how many times as much energy an earthquake of magnitude 7.0 releases as one of magnitude 5.0, Prakash wrote:
"Each step of magnitude is 10 times, so the energy is $10 \times 10 = 100$ times."

2 Read the data [4]

Three seismograph stations record the same earthquake. Take the P waves' speed as 7.0 km/s and the S waves' as 4.0 km/s.

Station	X	Y	Z
S waves after P waves (s)	6.4	12.9	22.5

i. Which station is nearest the earthquake?
ii. Find the distance of each station from it.
iii. How could the three distances be used to find where the earthquake was?

3 Predict, then explain [3]

Write your prediction first, then explain it.

An earthquake shakes Kathmandu. Predict the order in which a seismograph there records the P, S, Rayleigh and Love waves, and which a person feels as a sharp jolt and which as the ground rolling like a boat. Then explain.

4 Show that [3]

P waves travel at v_P and S waves at v_S. Show that the distance to an earthquake is $d = \Delta t \dfrac{v_P v_S}{v_P - v_S}$, where Δt is the time between their arrivals.

5 Estimate it [3]

The first wave LIGO caught changed each 4 km arm by about 4×10^{-18} m. Estimate this as a fraction of the arm's length. If Nepal, about 800 km long, were stretched by the same fraction, by how much would it change?

6 Which explanation fits? [2]

One LIGO detector records a sudden jump in its signal; the other, 3000 km away, records nothing at that time. Explanation A: a gravitational wave passed. Explanation B: something shook that detector locally. Which fits? Why?

7 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Sushila wrote: "The epicenter is the point deep underground where the rock first slips. Gravitational waves travel more slowly than light. The Higgs boson was found at NASA in 1964."

8 Work backwards [3]

One earthquake releases 250 times as much energy as another of magnitude 5.0. Find the magnitude of the first. How many times taller are its waves on a seismograph?

9 Compare [3]

Compare Rayleigh and Love waves: how each moves the ground, which arrives first, and what kind of ground each needs.

10 What if? [2]

What if the Earth's outer core were solid? What would seismographs on the far side of the Earth from an earthquake record that they don't now?

11 Make your own [2]

Write an earthquake problem whose answer is "the earthquake is 112 km away", using the gap between the P and S waves. Solve it to show it works.