Unit 26 · Recent Trends in Physics

HARDER PRACTICE QUESTIONS

Full marks 29

Write your answers on separate paper. Show your working. Take $c = 3.0 \times 10^8$ m/s, $G = 6.67 \times 10^{-11}$ N m^2/kg^2, the Sun's mass 1.99×10^{30} kg and $H_0 = 70$ km/s per Mpc.

1 Spot the error [3]

Find the mistake in the working and correct it.

Saurav found the charge of the negative pion, π^-, made of $\bar{u}d$:
"The up quark has $+\frac{2}{3}e$ and the down quark $-\frac{1}{3}e$, so $Q = +\frac{2}{3}e - \frac{1}{3}e = \mathbf{+\frac{1}{3}e}$."

2 Work backwards [3]

A hydrogen line that is 486.1 nm in the laboratory is observed at 500.0 nm in a galaxy's light. How far away is the galaxy?

3 Check the readings [3]

A student's table of galaxies reads:

Distance (Mpc)	10	20	40	60	80
Speed (km/s)	700	1,400	2,800	3,000	5,600

Find H_0 from the readings that agree, and say which reading doesn't fit Hubble's law and what it should be.

4 Can it happen? [3]

Check each reaction for charge and baryon number, and say whether it can happen.

i. $p + p \to p + p + n$

ii. $p + \bar{p} \to \pi^+ + \pi^-$

5 A real setting [3]

The black hole at the center of our galaxy has a mass of about 4 million Suns.

i. Find its Schwarzschild radius.

ii. Compare it with the distance from the Earth to the Sun, 1.5×10^{11} m.

6 Estimate it [2]

To what size would the Earth (mass 6.0×10^{24} kg) have to be squeezed to become a black hole?

7 Predict, then explain [3]

Write your prediction first, then explain it.

Astronomers argue over whether H_0 is 67 or 73 km/s per Mpc. Predict which value gives the older universe, then explain. Find both ages (1 Mpc $= 3.09 \times 10^{22}$ m, 1 year $= 3.16 \times 10^7$ s).

8 Which explanation? [2]

Nearly every galaxy is moving away from us. Rohit says this proves that our galaxy is at the center of the universe. Smriti says every galaxy would see the same. Who is right? Explain.

9 Correct the misconceptions [3]

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

> Shristi wrote: “Neutrinos have no mass at all. A boson must have an even spin, like 0 or 2. Dark matter has been seen in telescopes as dark clouds of gas.”

10 Think [2]

Quarks have never been found on their own. Why, then, do physicists believe they exist?

11 Make your own [2]

Using up, down and strange quarks and antiquarks, make one baryon and one meson, each with a charge of +e. Show their charges and baryon numbers.