

Computer Marked Assignment

Make sure you know how to use the CMA form: detailed instructions are given in your student handbook (or supplement).

You are strongly advised to attempt every question in this assignment.

If you do not wish to answer a question, pencil across the 'don't know' cell ('?').

If you think that a question is unsound in any way, pencil across the 'unsound' cell ('U') in addition to pencilling across either an answer cell or the 'don't know' cell.

Note For each question, you **must** pencil across either the required number of answer cells or the 'don't know' cell.

Q1 and Q2 These questions concern a galaxy at a distance of 1 500 Mpc with a redshift of 0.25.

Q1 Using this data for the galaxy, find a value for H_0 . Select the *one* item from the key that is closest to your answer.

KEY for Q1

- A 2.75 km s⁻¹ Mpc
- B 50 km s⁻¹ Mpc
- C 375 km s⁻¹ Mpc
- D 2 750 km s⁻¹ Mpc
- E 2.75 km s⁻¹ Mpc⁻¹
- F 50 km s⁻¹ Mpc⁻¹
- G 375 km s⁻¹ Mpc⁻¹
- H 2 750 km s⁻¹ Mpc⁻¹

Pencil across *one* cell in row 1.

Q2 Which *two* of the caveats listed in the key might be applied to this result? Select *two* items from the key.

KEY for Q2

- A The effects of dark matter have been neglected.
- B It has been assumed that the redshift is entirely due to the Hubble flow.
- C It has been assumed that the linear relationship between redshift and distance holds.
- D The expansion of space has been ignored.
- E The result implies that the age of the universe is less than the age of globular clusters.
- F It has been assumed that galaxies were the same then as now.

Pencil across *two* cells in row 2.

Q3 If $H_0 = 50 \text{ km s}^{-1} \text{ Mpc}^{-1}$, find the critical density ρ_c . Express ρ_c in units of galaxies per megaparsec-cubed. You may take the mass of a typical galaxy to be $10^{11} M_\odot$. Select the *one* item from the key that is closest to your answer.

KEY for Q3

- A 100 galaxies Mpc⁻³
- B 10 galaxies Mpc⁻³
- C 1 galaxy Mpc⁻³

- D 0.1 galaxy Mpc⁻³
- E 0.01 galaxy Mpc⁻³
- F 0.001 galaxy Mpc⁻³

Pencil across *one* cell in row 3.

Q4 An observed cluster of galaxies is approximately spherical, with radius 1 Mpc. It contains about 1 000 galaxies. If the mass of the average galaxy is $10^{11} M_\odot$, calculate the Schwarzschild radius for a mass equal to that of the cluster, expressing your answer in Mpc. Select the *one* item from the key that is nearest to your answer.

KEY for Q4

- A 10 Mpc
- B 1 Mpc
- C 10^{-1} Mpc
- D 10^{-2} Mpc
- E 10^{-3} Mpc
- F 10^{-4} Mpc
- G 10^{-5} Mpc
- H 10^{-6} Mpc

Pencil across *one* cell in row 4.

Q5 Which *one* of the statements in the key is correct? Select *one* item from the key.

KEY for Q5

- A The gravitational effect of the large number of photons in a cluster of galaxies is a significant factor in the gravitational binding of the cluster.
- B If a cluster of galaxies has a size less than its Schwarzschild radius then it is bound to collapse.
- C ρ_c is a constant; it does not change as the Universe evolves.
- D ρ_c includes baryonic matter and dark matter but does not include the energy density.
- E General relativistic effects, which are ignored in this Course, mean that the expression obtained for ρ_c here is not, in fact, correct.

Pencil across *one* cell in row 5.