BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1998
COSMOLOGY
DISTINCTION COURSE
MODULES 1, 2 AND 3

(60 Marks)

Time allowed—One hour
(Plus 5 minutes reading time)

DIRECTIONS TO CANDIDATES

- A data sheet is attached to this paper.
- Board-approved calculators may be used.

Section I (8 marks)

- Attempt FOUR questions.
- Answer this Section in a SEPARATE Writing Booklet.
- Each question is worth 2 marks.
- Allow about 8 minutes for this Section.

Section II (12 marks)

- Attempt BOTH questions.
- Answer this Section in a SEPARATE Writing Booklet.
- Each question is worth 6 marks.
- Allow about 12 minutes for this Section.

Section III (40 marks)

- Attempt BOTH questions.
- Answer each question in a SEPARATE Writing Booklet.
- Each question is worth 20 marks.
- Allow about 40 minutes for this Section.

SECTION I

(8 Marks)

Attempt FOUR questions.

Each question is worth 2 marks.

Answer this Section in a SEPARATE Writing Booklet.

QUESTION 1

Describe the technical advances during the Second World War (1939–1945) which spurred the development of radio astronomy.

QUESTION 2

The photographs below illustrate typical examples of four classes of astronomical objects. Name each CLASS and arrange the examples in order of increasing linear size.

FIG. 1

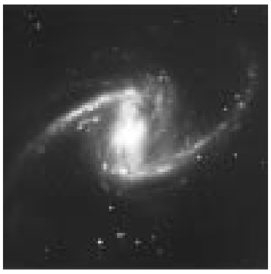


FIG. 2

FIG. 3

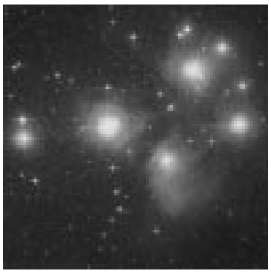
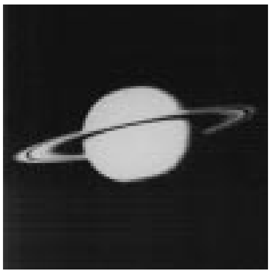


FIG. 4



QUESTION 3

Why are infra-red detectors for large telescopes cooled to very low temperatures?

QUESTION 4

Explain the difference between the Cosmological Principle and the Perfect Cosmological Principle.

SECTION I. (Continued)

QUESTION 5

Describe ONE major objection, in the sixteenth century, to general acceptance of the Copernican description of the solar system.

QUESTION 6

The HIPPARCOS astrometric satellite has measured reliable parallaxes of 5 milliarcseconds. To what distance (in parsecs) does it probe into our galaxy?

SECTION II

(12 Marks)

Attempt BOTH questions.

Each question is worth 6 marks.

Answer this Section in a SEPARATE Writing Booklet.

QUESTION 7

What are the advantages in linking several telescopes as an interferometer? Briefly outline the technical problems in making the links.

QUESTION 8

(a) Discuss the use of supernovae as ‘standard candles’.

(b) The Type 1a supernova 1990 N discovered in galaxy NGC 4639 had an observed magnitude at peak brightness of $V(\text{max}) = 12{\cdot}61$.

The maximum absolute magnitude for this supernova is believed to be $M_V(\text{max}) = -19{\cdot}39$. Calculate the distance to NGC 4639.

SECTION III

(40 Marks)

Attempt BOTH questions.

Each question is worth 20 marks.

Answer this Section in a SEPARATE Writing Booklet.

QUESTION 9

Information about the Universe arrives at Earth mainly through electromagnetic radiation. Describe the various bands in the electromagnetic spectrum, and, for each band of radiation, discuss:

(a) the methods and locations used to detect the radiation;

(b) the typical objects in the Universe emitting such radiation.

QUESTION 10

Astronomical measurements alter our concept of the Universe.

Describe the new measurements that became possible in the 50 years between the application of spectroscopy to astronomy by William Huggins in 1868 and the classification of nebulae up to 1918.

End of paper

Cosmology Distinction Course

Physical Constants and Conversion Factors

Recommended values

Abstracted from the consistent set of constants in CODATA Bull. No. 63 (1986) by the Royal Society, the Institute of Physics, and the Royal Society of Chemistry.

The number in parenthesis after each value is the estimated uncertainty (standard deviation) of the last digit quoted.

speed of light in a vacuum	c	$2{\cdot}997\,924\,58 \times 10^{8}$ m s^{-1} (exact)
permeability of a vacuum	μ_0	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of a vacuum, $[\mu_0 c^2]^{-1}$	ϵ_0	$8{\cdot}854\,187\,817\ldots \times 10^{-12}$ F m^{-1}
elementary charge (of proton)	e	$1{\cdot}602\,177\ 33(49) \times 10^{-19}$ C
gravitational constant	G	$6{\cdot}672\,59(85) \times 10^{-11}$ N m^{2} kg^{-2}
Planck constant	h	$6{\cdot}626\,0755(40) \times 10^{-34}$ J s
Avogadro constant	N_A	$6{\cdot}022\,1367(36) \times 10^{23}$ mol^{-1}
molar gas constant	R	$8{\cdot}314\,510(70)$ J K^{-1} mol^{-1}
Boltzmann constant	k	$1{\cdot}380\,658(12) \times 10^{-23}$ J K^{-1}
unified atomic mass constant	m_u	$1{\cdot}660\,5402(10) \times 10^{-27}$ kg
rest mass of electron	m_e	$9{\cdot}109\,3897(54) \times 10^{-31}$ kg

SI secondary units

astronomical unit	AU	$1{\cdot}495\,978 \times 10^{11}$ m
parsec	pc	$3{\cdot}0856 \times 10^{16}$ m = $3{\cdot}262$ ly
Gregorian calendar year	y	$365{\cdot}2425$ days = 31 556 952 s
jansky	Jy	10^{-26} W m^{-2} Hz^{-1}

Indicative values

earth mass	$5{\cdot}977 \times 10^{24}$ kg
solar mass, $M_\odot$	$1{\cdot}989 \times 10^{30}$ kg
galaxy mass	$10^{11}\ M_\odot$
Hubble constant, H_0	$100\,h$ km s^{-1} Mpc^{-1} (typically h ranges from 1 to 0·5)

Conversion factors

distance (light-year)	ly	$9{\cdot}460 \times 10^{15}$ m = 63 240 AU
energy (erg)	erg	10^{-7} J
magnetic field (gauss)	G	10^{-4} T
wavelength (angstrom)	Å	10^{-10} m