CANADIAN ASSOCIATION OF PHYSICISTS

UNIVERSITY PRIZE EXAMINATION

Monday, March 5, 1979

2:00 p.m. to 5:00 p.m.

Examination Committee:

Dr. C. J. Bland
Dr. C. E. Challice
Dr. R. Chatterjee
Dr. H. R. Krouse (Chairman)

Completed booklets to be sent to:

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The University of Calgary
Calgary, Alberta
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The committee congratulates you for making the effort to participate in this examination. We will be most surprised if a candidate is able to complete all questions satisfactorily. Please attempt as many questions as you wish in whole or in part but remember to *answer each question in a separate booklet or on a page from a booklet--always including the question number and your name.* The points in the left hand margin give the proportional value of each question.

ONLY slide rules or pocket electronic calculators <u>without</u> stored memory are allowed.

Constants and Expressions:

$$E^2 = p^2c^2 + m^2c^4$$

Rest mass of the proton = 938 MeV/c^2 = 1.67 x 10^{-27} kg.

Charge on the electron = 1.6 x 10^{-19} Coulombs.

Radius of the earth = 6.4 x 10^6 metres.

Speed of light in vacuum = 3.0 x 10^8 metres sec^{-1}.

Thermal conductivity of ice = 2.24 watts metre^{-1} °C^{-1}.

Latent heat of fusion of water = 3.35 x 10^5 joules kg^{-1}.

Horizontal geomagnetic flux density at equator = 3 x 10^{-5} webers/m^2

POINTS

20   1.   Physics is basic to an understanding of all sciences and life in general. Following a brief general introduction, develop this theme in an area of your choice (e.g., transportation vehicles, communication, biology and medicine, engineering, philosophy and religion, energy and conservation policy, etc.).

15   2.   A symmetrical top is a right circular cone of vertical height h, base radius a, and uniform density ρ. It is pivoted (frictionlessly) at a point on a horizontal table. It is set rotating about its symmetry axis with an angular velocity ω. Find its precessional angular velocity if the vertical angle θ of the symmetry axis remains constant.

15   3.   (a) An eclipse of the sun is an infrequent event which generates a great deal of concentrated research activity. Describe one experiment which would provide important scientific data under these conditions. Provide experimental and theoretical details.

           (b) Can the features of an eclipse be duplicated by suspending an object some distance in front of a telescope so as to block out the central disk of the sun? Explain.

15   4.   An exceptionally cold winter this year has resulted in the freezing over of all but one of the Great Lakes. If a static body of water is covered by a 5 cm thick layer of ice and the air temperature above it remains at -30°C, approximately how long will it take for the ice to double in thickness?

15   5.   (a) Given Maxwell's Equations as applied to a progressive alternating electromagnetic field in free space, approaching the smooth flat surface of a transparent and non-magnetic dielectric, derive Snell's law of refraction and the relationship between the refractive index and the electrical constants of the media.

           (b) This derivation will produce no indication of dispersion, although in practice, dispersion is observed. What assumptions have been made in the derivation which have to be qualified to account for this dispersion.

10   6.   A wire of unstretched length ℓ_0 is given a static Young's modulus test by suspending a mass m from the end of the wire. The elongation is $10^{-3}\ell_0$. The same wire is now clamped horizontally between two supports a distance ℓ_0 apart and the same mass m is suspended from its midpoint. Find the depression of the midpoint and the tension in the wire.

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10   7.   The earth's magnetic field deflects cosmic rays of lower momenta away from the earth. Assuming that the earth's field is that of a dipole, calculate the maximum energy at which protons in cosmic rays are prevented from arriving at the earth by the geomagnetic field.

10   8.   A particle is in an elliptic orbit due to an attractive potential $-\frac{k}{r}$. The eccentricity of the orbit is e. Given that the total energy E and the angular momentum vector $\vec{L}$ are constants of the motion, prove that

$$\vec{R} = \vec{p} \times \vec{L} - k\mu\hat{r}$$

is also a constant of the motion where μ is the reduced mass and $\vec{p}$ the momentum. (Note: $\hat{r}$ denotes a unit vector.)

10   9.   Explain, using diagrams, how a holographic image may be formed from an object.

10   10.   Cite evidence for "magic numbers" of nucleons in a nuclear structure. Why do the magic numbers in nuclear structures differ from the numbers associated with filled electron shells in atomic structures?

5   11.
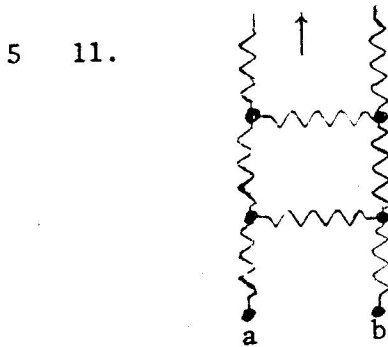
Fig.1

What is the resistance between points a and b of the infinite resistor ladder (Fig.1)? Each resistor has resistance r.

5   12.   A parallel transmission line is constructed of two parallel wires of radius a and distance of separation b. A current flows up one wire and down the other. The inductance per metre is given by

$$L = \frac{\mu_0}{4\pi}\left[1 + 2\,\ell n\,\frac{b^2}{a^2}\right]$$

What is the capacitance per metre?

TOTAL
POINTS   140

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