

CANADIAN ASSOCIATION OF PHYSICISTS

UNIVERSITY PRIZE EXAMINATION

Tuesday, March 18, 1986

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

Examination Committee

Dr. C.J. Bland  
Dr. R. Chatterjee  
Dr. D.J.I. Fry  
Dr. H.R. Krouse  
Dr. D. Venkatesan (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 without stored memory are allowed.

## Points

- 20
1. A uniform disk of mass  $M$ , radius  $R$  has its axis horizontal and is free to rotate without friction about its centre. A fly of mass  $m$  starts from rest at the bottom of the disk and walks along the rim at constant velocity  $v$  relative to the disk.
    - i) What is the initial angular velocity of the disk?
    - ii) What is the angular velocity of the disk at the time the fly reaches the top (consider both cases that the fly continues to walk or stops walking at the top).
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2. The water in a U-shaped tube is displaced an amount  $\Delta X$  from equilibrium. (The level in one side is  $2\Delta X$  above the level in the other side). The total length of the water in the tube is  $\ell$ . After displacement the water is released and allowed to oscillate in the U-tube.
    - a) Show that the oscillations take place with simple harmonic motion.
    - b) Derive an expression for the period of the motion.
- 10
3. A coffee mug consists of a handle-less hollow cylinder, closed at one end, open at the other and of uniform surface density. Coffee is gradually poured into the mug. Show that the centre of mass of the system is lowest when it is on the surface of the liquid.
- 5
4. Calculate the change in entropy of 1 kg of ice (initially at  $0^\circ\text{C}$ ) when it is completely vapourized. The latent heat of fusion,  $L_f$  is  $3.33 \times 10^5$  J/kg; the latent heat of vaporization,  $L_v$  is  $22.6 \times 10^5$  J/kg, and the mechanical equivalent of heat is 4186 J/kcal.
- 15
5. During a very heavy wind in February, an observer noticed that hydro lines were oscillating in their second normal mode. Given that the distance between poles was 40 m and the sag in the lines was 2 m, estimate the observed frequency.

Treat the loading of the cable as per unit length of cable or per unit distance in the  $x$  direction as you please.

When calculating the wave velocity, use the approximation that  $T = T_0$  the tension at the centre.

8. The wave function for a particle moving in a potential well  $V(x)$  is given by:

$$\Psi = (8\sqrt{\pi})^{-1/2} (4\beta^2 a x^2 - 2)e^{-1/2(\beta^2 x^2)}$$

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where  $\beta$  is a constant,

- find the potential  $V(x)$  assuming that  $V(0) = 0$ , and also the energy eigenvalue.
- discuss whether the particle is in the ground state or in any one of the excited states.
- is the parity one of the constants of motion or not?

9. Answer one of the following:

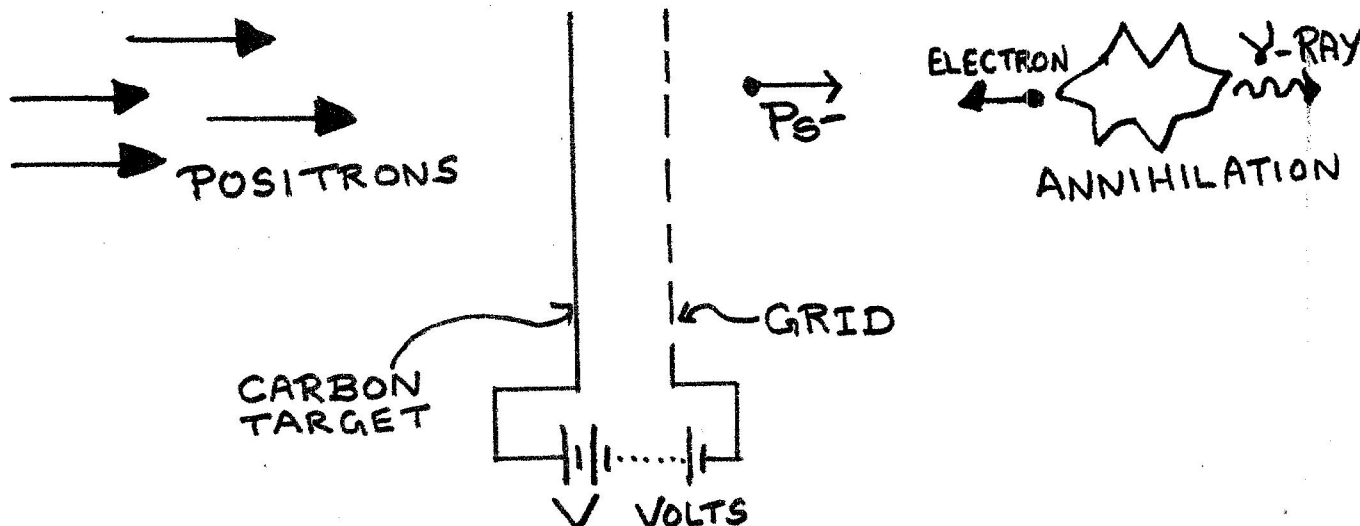
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What concept of the Heliosphere has emerged as a consequence of a quarter century of space exploration?

OR

The International Halley's Comet Watch is a momentous collaborative effort of many nations. What are the programs of study and what are they expected to add to our knowledge of our solar system?

10. There has been a recent report (Physical Review Letters 46, 719, March 1981) of a clever experiment to produce and detect  $\text{Ps}^-$ , a positronium with two electrons in orbit about it.



13. You must start your car at  $-40^{\circ}\text{C}$ . You should;

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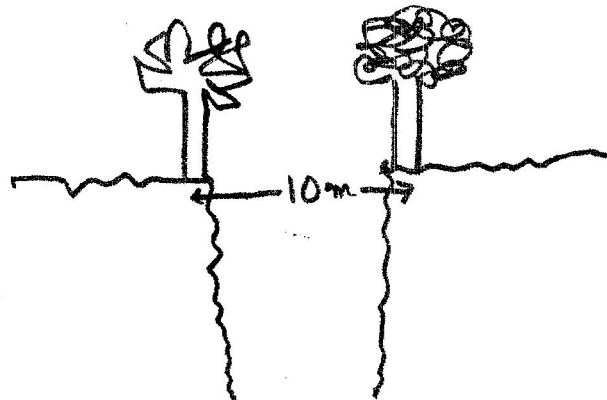
- (a) start it without any accessories turned on
- (b) start it with the lights on
- (c) turn the lights on for a brief period, turn them off and then start the car.

You have to justify your answer with suitable explanations.

14. You have to cross a gorge using two lengths of very old rope which are each 12 m long. You have a friend on the other side and a tree on each side with trunks 20 cm in diameter and 10 m apart (center to center). The ropes are least likely to break if:

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- i) they are twisted together and stretch across the gorge and you cross hand over hand
- ii) the ends of the rope are tied together so you can cross on a very slack rope
- iii) the ropes are stretched across the gorge, one 2.0 m above the other so you can place your two feet on the bottom rope while hanging on to the top rope with your hands.



15. Let  $F(q,p)$  be any function of the coordinate  $q$  and the momentum  $p$  which are related by the Hamilton's Equations

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$$\delta q / \delta t = \delta H / \delta p$$

and  $\delta p / \delta t = -\delta H / \delta q$  where  $H$  is a Hamiltonian

- (a) write down the expression for the Poisson bracket of  $\{F,H\}$
- (b) using (a) show that:

$$i) \{q_{\sigma}, p_{\chi}\} = \delta_{\sigma\chi}$$

$$\text{where } \delta_{\sigma\chi} = 1 \text{ if } \sigma = \chi$$

$$= 0 \text{ if } \sigma \neq \chi$$

$$ii) \{q, H\} = \delta H / \delta p$$

- (c) under what condition can you obtain a conservation law from the Poisson bracket? Can you provide an example from your physics background?

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19. A toy submarine drifts with water flowing in a pipe of varying widths. Changes in speed cause the shifting of a heavy mass suspended by springs inside the sub as shown. As the sub drifts from regions A to B, and then to C, the mass shifts:

- (a) backward in going from A to B, then forward from B to C
- (b) forward in going from A to B, then backward from B to C
- (c) not at all

