



1.3. In view of the uncertainty principle, can you measure a position with low uncertainty (with high precision)?

(1)

Explain.

(3)

**Question 2 Fluid Mechanics (14 marks)**

2.1. The large piston of a hydraulic lift is 0.300 m in diameter. What pressure (in atmospheres) must be applied at the small piston in order to lift a car of mass  $1.20 \times 10^3$  kg? (6)

2.2. A slab of ice floats on a freshwater lake. What minimum mass must the slab have for a 45.0 kg person to be able to stand on the floating ice slab without getting their feet wet? (8)

**Question 3 Oscillations and Waves (14 marks)**

- 3.1. What is the intensity (in  $\text{W m}^{-2}$ ) of a sound whose level is at the human threshold of pain (= 120 dB)? The threshold of hearing is at an intensity of  $1.0 \text{ pW m}^{-2}$ . (4)

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- 3.2. A block of unknown mass is attached to a spring with a spring constant of  $6.50 \text{ N/m}$  and undergoes simple harmonic motion with an amplitude of  $10.0 \text{ cm}$ . When the block is halfway between its equilibrium position and point of maximum displacement, its speed is measured to be  $30.0 \text{ cm/s}$ . Determine the mass of the block. (5)

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- 3.3. Show that wave function  $y(x, t) = e^{b(x-vt)}$  is a solution of the linear wave equation (Given below) where  $b$  is a constant. (5)

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 y}{\partial t^2}$$

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**Question 4 Thermodynamics (14 marks)**

4.1. A copper pot with a mass of 0.500 kg contains 0.170 kg of water, and both are at a temperature of 20.0 °C. A 0.250 kg block of iron at 85.0 °C is dropped into the pot. Find the final temperature of the system, assuming no heat loss to the surroundings. (6)

4.2. Describe how a refrigerator cycle works. (5)  
 Include a well labelled block diagram illustrating the cycle. (3)

**Question 5 Optics (14 marks)**

5.1. A person is looking into an aquarium containing a fish. One ray of light coming from the fish is shown in the diagram (bold line). As illustrated by the dotted line, that ray makes the fish appear to be in the position shown.

In the same diagram, indicate with a clear and visible 'dot', the approximate actual position of the fish inside the aquarium. (2)



Briefly justify your answer. (2)

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5.2. A shaving or makeup mirror is designed to produce an upright image of your face enlarged by a factor of 1.40 when your face is placed 20.0 cm in front of the mirror.

What type of mirror is this and determine its focal length. (6)

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5.3. At what angle will 510 nm light produce a second-order maximum when falling on a grating whose slits are  $1.35 \times 10^{-3}$  cm apart? (4)

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6.3. Define the unit 'Ampere'.

(3)

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**Question 7 Nuclear Physics (16 marks)**

7.1. The half-life of radium-226 is  $1.62 \times 10^3$  years. How many radium atoms decay in 1.00 s in 1.00 g sample of radium? [1 year = 365.25 days]

(8)

7.2. What is the ‘binding energy’ and ‘binding energy per nucleon’ for

7.2.1.  ${}^4\text{He}$ ? (4)

7.2.2.  $^{238}\text{U}$ ? (4)