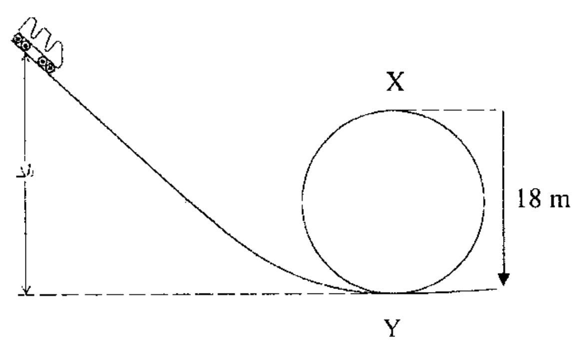
The Open University of Sri Lanka
Department of Physics
Bachelor of Science Degree Program
Level 3
PHU3300- General and Thermal Physics
Final Examination – 2024

Duration - two hours (2 hrs.)

Date: 15.12.2024 **Time: 9.30am - 11.30am**

ANSWER FOUR QUESTIONS ONLY

1. The diagram shows the carriage of a rollercoaster is about to enter a vertical loop of diameter 18.0 m. The carriage is initially at rest at a height Δh above the bottom of the loop.



(a) (i) Show that a passenger remains in contact with his seat at the top(X) of the ride, Determine the minimum speed of the car at the top of the loop.

(ii) Calculate the minimum value of Δh that will enable the passenger to remain in contact with his seat at the top of the loop.

(b) During one particular ride, the speed of a car at the bottom of the loop was 20 m s^{-1}.

(i) Calculate the acceleration of the passenger at the bottom of the loop as a multiple of g, the acceleration due to gravity.
(ii) Determine the minimum speed of the car at the top of the loop.

(c) A stone of mass 0.25 kg tied to the end of a string which is whirled round in a circle of radius 1.5 m with a speed of 40 rev./min in a horizontal plane.

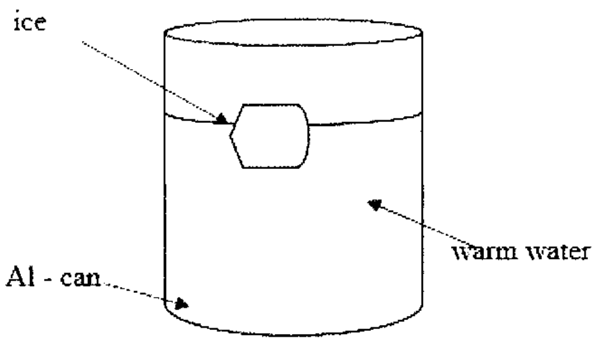
(i) What is the tension in the string?
(ii) What is the maximum speed with which the stone can be whirled around if the string can withstand a maximum tension of 200 N?

40

2. (a) Define the following physical quantities.

(i) Specific heat capacity of a material
(ii) Latent heat of fusion of ice.

During melting, a solid becomes liquid with little or no change in volume.



(b) An aluminum can with a mass of 160 g contains a mass of 330 g of warm water at a temperature of 38 °C, as shown in Figure.

A mass of 48 g of ice at −18 °C is taken from a freezer and put into the water. The ice melts and the final temperature of the can and its contents is 23 °C. Data for the specific heat capacity c of Aluminum, ice, and water are given in the table

	$C/J\ g^{-1}K^{-1}$
Aluminum	0.910
Ice	2.10
Water	4.18

Assuming no exchange of thermal energy with the surroundings,

(i) show that the loss in thermal energy of the can and the warm water is 2.3×10^4 J,
(ii) use the information in **(i)** to calculate a value L for the specific latent heat of fusion of ice (L).

(c) (i) State ideal gas law. Explain the major difference between Ideal gas and real gas.

(ii) A helium weather balloon is filled when the atmospheric pressure is 10^2 kPa and the temperature is 18 °C. Its volume under these conditions is 1.6×10^4 L. Upon being released, it rises to an altitude where the temperature is -8.6 °C, and its volume increases to 4.7×10^4 L. What is the internal pressure of the balloon at this altitude?

3. (a) Derive an expression for the following,

(i) Gravitational field intensity of a point on the earth's surface.
(ii) Tangential speed of the satellite around the earth using standard symbols.

(b) A Space Telescope (ST) was launched into a low Earth orbit above the Earth's atmosphere. ST orbits the Earth in a circular orbit with a speed of 8 km s^{-1}. Mass of Earth = 6×10^{24} kg, Radius of Earth = 6.4×10^6 m.

(i) Determine the height of the ST above the surface of the Earth.
(ii) Calculate the total energy of ST. Mass of ST = 11 600 kg

(c) (i) What is a Geostationary satellite? Explain the advantages of a Geostationary satellite.

(ii) Scientists are constructing a space station with enormous solar panels. The space station would be positioned in a geostationary orbit. A geostationary orbital space station is located above the equator and has a 24-hour period.

Calculate the height h of the space station above the equator when it is in a geostationary orbit. Mass of Earth = 6.00×10^{24} kg, 24 hours = 8.64×10^4 s

4. A small helium balloon is released into the air. The balloon initially accelerates upwards.

(a) (i) Write down the expression for the resultant force 'F' exerted on the balloon
(ii) Show that the balloon reaches a constant upward speed eventually.
(iii) Calculate the value for the viscous drag force acting on the balloon at this speed. The balloon may be considered as a sphere with a radius of 12 cm, the density of air = 1.2 kg m^{-3} mass of unfilled balloon = 4.0 g, and mass of helium in balloon = 1.2 g

(b) (i) Define the Terminal velocity of a solid ball inside a liquid and derive an expression for terminal velocity.

(ii) In Millican's oil drop experiment, what is the terminal velocity of an uncharged drop of radius 3×10^{-5} m and density 1.5×10^3 kg/m^3. Take the viscosity of air at the temperature of the experiment to be 1.8×10^{-5} Pa s. How much is the viscous force on the drop at that speed? Neglect the buoyancy of the drop due to air.

5. (a) (i). Define coefficients of surface tension.

(ii). Define the following terms:
A - Free surface energy a liquid surface
B - Capillary action of a capillary tube.
C- Angle of contact

(iii). Derive an expression for the rise of liquid in a capillary tube immersed in the liquid.

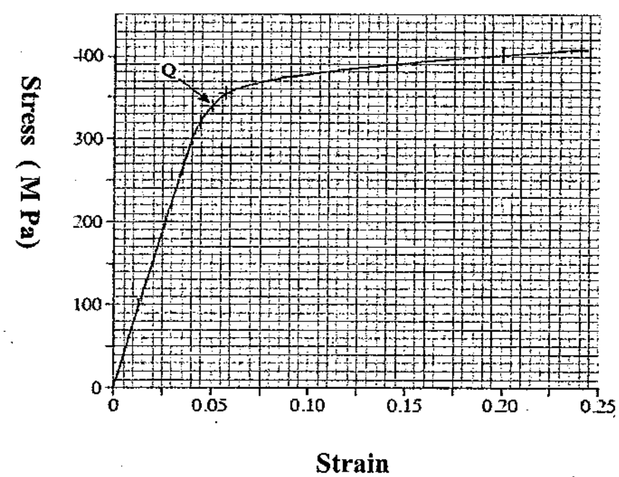
(b) In a glass capillary tube, water rises 9.0 cm while mercury falls 3.4 cm. Assume water-glass and mercury-glass contact angles are 0° and 135°, respectively. Determine the ratio of surface tensions of mercury and water.

(c) (i) Write down the expression for the excess pressure in a soap bubble.

(ii) There is a soap bubble of radius 3.6×10^{4} m in air cylinder which is originally at a pressure of 10^{5} N m^{2} . The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate the pressure of air in the cylinder.

6. State the Hooke's law of Elasticity.

(a) Below is the stress - strain graph that the engineer obtains for the metal wire.



(i) An engineer has labeled point Q on the graph. This is the moment at which the behavior of the material changes. State the name of this point and describe how a metal behaves after exceeding it.

(ii) Use the graph to determine the Young's modulus of the metal.

(iii) Show by drawing on the graph how you would expect the stress vary with strain as the stress is reduced.

(b) A Metal wire of length 3 m and diameter 0.6 mm is stretched by a load of 10 kg. Find the

(i) longitudinal stress,
(ii) longitudinal strain,
(iii) Increase in length.

(c) What mass must be suspended from a free end of steel wires of length 2 m and diameter 1 mm to stretch it by 1mm? (Young's modulus of steel = 2×10^{11} N/m^2).

-The End-