00392

THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF PHYSICS
BACHELOR OF SCIENCE DEGREE PROGRAMME–2016/2017
LEVEL 03
PYU 1160/3160 – GENERAL AND THERMAL PHYSICS
FINAL EXAMINATION

TIME : TWO HOURs (2 hrs)

ANSWER <u>FOUR (04)</u> QUESTIONS ONLY

Date : 03.08.2017 **Time :** 9.30 am – 11.30 am

(1) Answer Part I or Part II

PART 1

State Bernoulli's theorem and write down the two applications of Bernoulli's theorem.

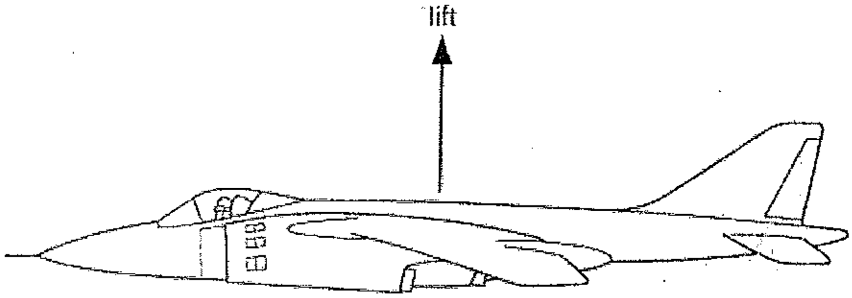


Figure shows an aircraft with an arrow indicating the lift force.

(a) An aircraft has a mass of 11 000 kg when fully loaded. The take-off speed is 180 km h^{-1} and is achieved using 750 m of runway starting from rest.

i Assuming that the acceleration is uniform, determine the time taken to reach the take-off speed.

ii Calculate the resultant force on the aircraft while accelerating along the runway.

iii Calculate the average power used to accelerate the aircraft on the runway.

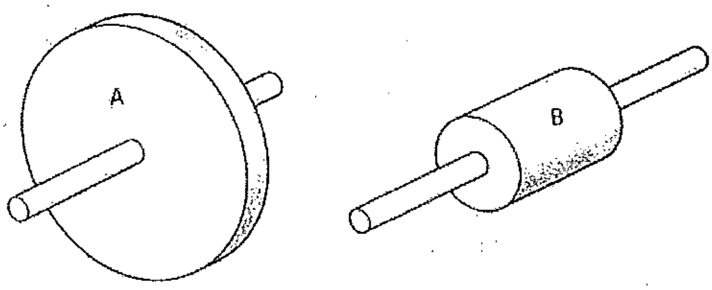
iv Explain why the power developed by the engines is much greater than the answer to **iii**.

(b) Jet aircraft cruise at a height of 10 000 m.

Why is it an advantage to cruise at 10 000 m rather than at a much lower height?

(c) The wings of an aircraft are seen to move up and down and undergo other vibrations when in flight. State and explain one property of the material used for the manufacture of the wings of an aircraft which is desirable in view of these vibrations.

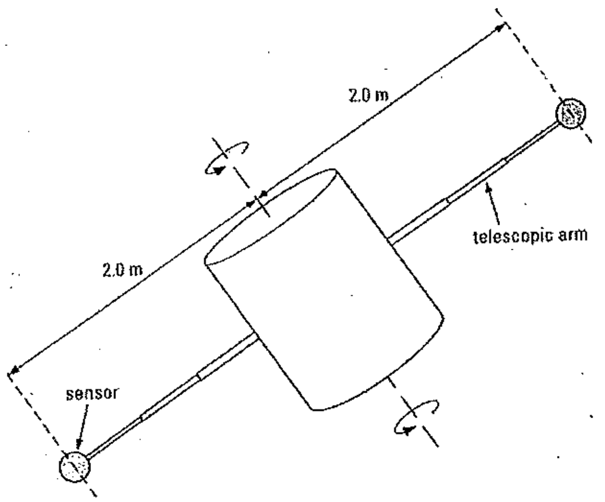
PART II



(a) i Define moment of inertia.

ii State which of wheels A and B has the greater moment of inertia. Give a reason for your answer. Consider A and B have the same mass.

(b) An orbiting satellite carries two sensors each of mass 2.5 kg at the ends of telescopic booms (Figure). When the booms are fully extended the centre of mass of each sensor is 2.0 m from the axis of the satellite, which spins at 0.10 rad s^{-1} about this axis, as shown in the diagram. The mass of each boom is negligible compared with that of the sensor. A motor can be used to retract the booms so that the sensors lie on the axis of the satellite and make negligible contribution to the moment of inertia of the satellite. Under these conditions the moment of inertia of the satellite about its axis is 100 kg m^2.



When the booms are fully extended,

i show that the moment of inertia of the satellite is 120 kg m^2.

ii calculate the rotational kinetic energy of the satellite when spinning at 0.10 rad s^{-1}.

(c) With the satellite spinning initially at 0.10 rad s^{-1}, the booms are fully retracted. Calculate

i the new rotational speed of the satellite, explaining your reasoning carefully,

ii the rotational kinetic energy of the satellite.

(2) Answer PART I or II

PART I

(a) i List the assumptions of the kinetic theory of gases.

ii Prove that, with the usual symbols, the pressure p of a gas is given by

$$p = \frac{1}{3}\rho c^2$$

where, ρ is density of the gas, and

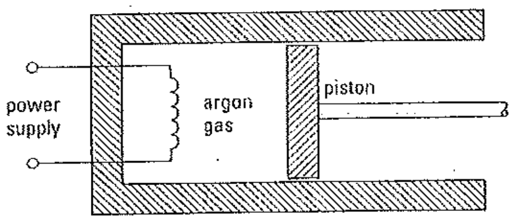
c^2 is the mean square velocity of gas molecules

iii By comparing this equation with the equation of state for 1 mole of an ideal gas, find an expression for the translational kinetic energy for 1 mole of the monatomic gas.

iv Hence show that the average translational kinetic energy per molecule of a monatomic gas is given by $\frac{3}{2}kT$ where k is the Boltzmann constant.

v 5 moles of helium at 27 °C are allowed to mix with 3 moles of neon at 127 °C. Calculate the temperature of the resulting mixture of gases. Assume no heat losses during the mixing process.

(b) i State, in words, the first law thermodynamics applied to the energy changes for a fixed mass of ideal gas.



ii 6.0 g of argon gas with molar mass 0.018 kg mol^{-1}, is contained at atmospheric pressure, 1.0×10^5 Pa, within a large thermally insulated cylinder by a perfectly fitting frictionless piston, as shown in Figure. A 5.0 W electrical heater is used to heat the gas for 25 s. The experiment is carried out twice under different conditions.

1. When the piston is fixed in position, the temperature rise is 30 K. Calculate the molar heat capacity of argon which these data give.
2. When the piston is free to move, the temperature rise is found to be 18K. Calculate the molar heat capacity of argon which these data give.

PART II

(a) (i) State the

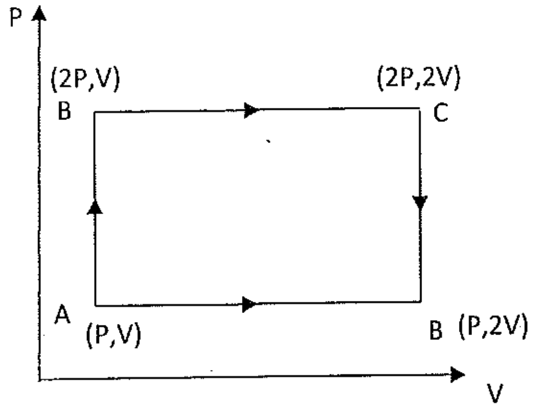
1.Zeroth Law of thermodynamics.

2.First law of thermodynamics

(ii) Discuss the application of the first law of thermodynamics to

1. Isothermal process
2. Adiabatic process

(b) An ideal mono-atomic gas is taken around the cycle. ABCDA as shown in P-V diagram. What is the work done during the cycle?



(c) One mole of oxygen is taken at 27 ^{0}C. It is isothermally expanded till the volume is doubled. Then, it is adiabatically compressed till the original volume is reached. Calculate the resulting temperature and the work done on the gas. Take $\gamma = 1.4$ and $R = 8.4$ J mol^{-1} K^{-1}.

(3.) **(a)** The gravitational Field strength of the earth at its surface is 9.81 N kg^{-1}.

Show that

i The acceleration of free fall at the surface of the Earth is 9.81 m s^{-2},

ii N kg^{-1} is equivalent to m s^{-2} in base units.

(b) Use the value of the gravitational field strength of the earth quoted in part **(a)**, together with the value of **G** (6.67×10^{-11} m^3 kg^{-1}s^{-2}), the gravitational constant, and of the radius of the earth(6.38×10^6m), to calculate the mass of the earth.

(c) Calculate the earth's gravitational field strength at a height of 0.12×10^6 m above the earth's surface.

(d) Explain briefly why an astronaut in a satellite orbiting the earth at this altitude may be described as weightless.

(e) At the surface of a planet P of radius r_p and mean density ρ_p the acceleration due to gravity is g_p. If planet Q has a radius of r_Q and mean density of ρ_Q, Show that the acceleration due to gravity g_Q at its surface is given by

$$g_Q = \frac{r_Q \rho_Q}{r_p \rho_p} g_p$$

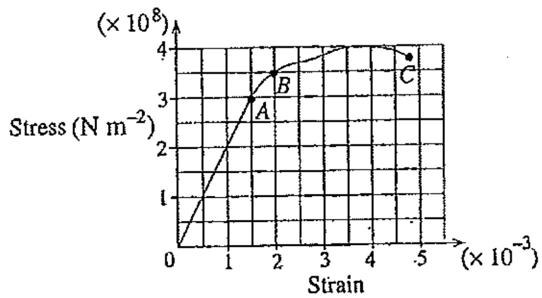
(f) A catapult can fire a pellet to a vertical height of 10.0 m on earth. It is taken to the moon which has a radius 0.27 times that of the Earth and which is composed of material of mean density 0.61 times that of the earth. Calculate

i the acceleration due to gravity on the Moon,

ii the height to which the pellet could be fired on the Moon.

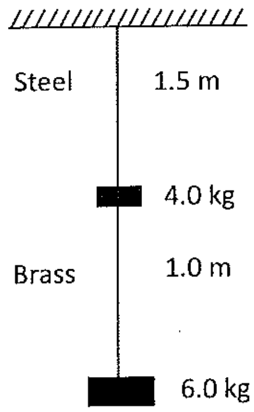
(4) (a) i Young's modulus E of a material in the form, of a wire is given by $E = \dfrac{F/A}{\Delta\ell/\ell}$. Here all the symbols have their usual meaning. Identify the terms in the expression.

ii Figure (1) shows the stress-strain curve for a uniform steel rod. Identify the points A, B and C.



iii Prove that the work done per unit volume in stretching wire is equal to ½ (stress × strain)

(b) Compute the elongation of steel and brass wire shown in Figure below. Unloaded length of steel wire = 1.5 m, unloaded length of brass wire = 1.0 m, diameter of each wire = 0.25 cm, Young's modulus of steel is 2.0×10^{11} Pa and that of brass is 0.91×10^{11} Pa. Take $g = 9.8$ N kg^{-1}.



(5) (a) Explain the following terms

i Streamline flow
ii Turbulent flow
iii Steady flow
iv Terminal velocity

(b) A small sphere is dropped from rest into a viscous fluid and its velocity is reached to a terminal velocity.

i Derive an expression for terminal velocity.
ii Draw the variation of displacement, velocity, acceleration of small sphere with time.

(c) Eight spherical drops of equal size fall vertically through air with a terminal velocity of $0.1\ ms^{-1}$. What would be the velocity if these eight drops were to combine to form one large spherical drop?

(d) Water flows horizontally through a pipe line of varying cross-section. If the pressure of the water equals 10 cm of mercury at a point where the velocity of the flow is $40\ cm\ s^{-1}$. What is the pressure of another point, where the velocity of the flow is $50\ cm\ s^{-1}$?

(6) (a) Define following terms.

i Angle of contact

ii Coefficient of surface tension of liquid.

iii What is the effect of temperature on the surface tension of a liquid?

(b) i Show that the surface energy per unit area of liquid film is numerically equal to the surface tension of the liquid.

ii A film of soap is formed on a rectangular frame of length 10 cm dipping into soap solution. The frame hangs from one arm of balance. An extra weight of 0.42 g must be placed in the other pan to balance the pull of the frame. Calculate the surface tension of the soap solution.