

## QUESTION ONE [8 Marks]

- (a) Newtons law of gravitation asserts that the attractive force between two bodies of mass  $m_1$  and  $m_2$  is proportional to the product of their masses divided by the distance  $r$  between them:

$$F = \frac{Gm_1m_2}{r^2}$$

Compute the units of  $G$  from the relation.

- (b) Consider the energy relation

$$E = al \sin(bt),$$

where  $E$  is energy,  $l$  is length and  $t$  is time.

- (i) What is the dimension of  $b$ ?
- (ii) What is the dimension of  $a$ ?

## QUESTION TWO [12 Marks]

Heat transfer on a body

The heat transfer rate per unit area  $q$  to a body from a fluid in natural convection is a function of the temperature difference between the body and the fluid,  $\Delta T$ , body length  $L$ , kinematic viscosity of the fluid  $\nu$ , thermal conductivity of the body  $\kappa$  and the thermal expansion coefficient  $\beta$ .

Using the Buckingham Pi theorem, find an appropriate dimensionless relationship. The dimensions of the measurable quantities are given in the table below:

Quantity	$q$	$\Delta T$	Length of body	$\nu$	$\kappa$	$\beta$
Dimension	$\frac{M}{T^3}$	$K$	$L$	$\frac{L^2}{T}$	$\frac{ML}{T^3K}$	$\frac{1}{K}$

## QUESTION THREE [8 Marks]

Find the general solution to the linear homogeneous PDE

$$2\frac{\partial u}{\partial x} + 3\frac{\partial u}{\partial y} + 8u = 0$$

subject to

$$u(x, 0) = \sin x.$$