

## Topic 2 – Practical 2

### *Determination of mass using balanced forces*

#### Safety

Wear safety glasses/goggles. The stands should be secured on the bench with clamps.

#### Apparatus and materials

- two stands and clamps (one tall and one short)
- free-run pulley wheel with rod
- strings (one long piece of string and one shorter with a loop at one end)
- mass hanger (100 g) and slot masses (several different masses)
- 'unknown' mass, labelled  $X$
- Protractor (or printout of protractor)
- top-pan balance

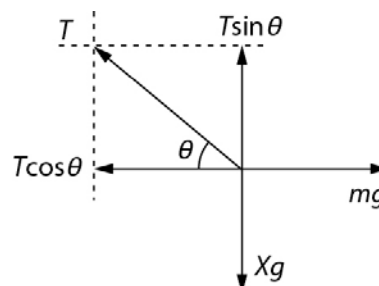
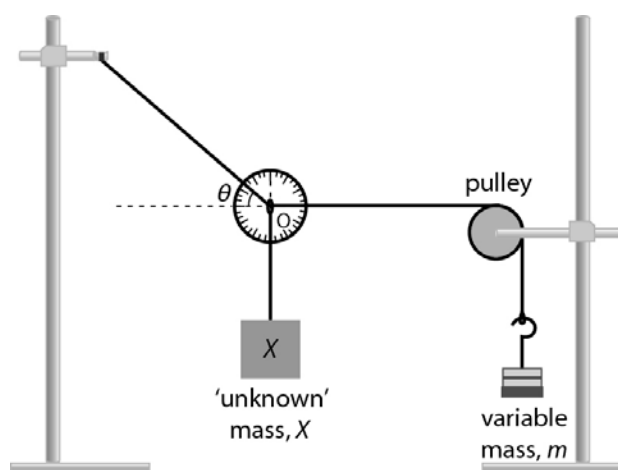
#### Introduction

In this practical, you will use your knowledge about forces in equilibrium to determine an unknown mass.

According to Newton's laws, the resultant force acting on an object that is stationary is zero, meaning that any force exerted must be balanced by another one in the opposite direction.

In the case of the setup of the diagram below, when point O is not moving then the three forces that act on it are in equilibrium (see force diagram on the right). This means that the resultant force on the  $x$ -axis is zero and the same applies for the resultant force on the  $y$ -axis. Therefore:

$$\begin{array}{l}
 x\text{-axis: } T \cos \theta = mg \Rightarrow T = \frac{mg}{\cos \theta} \\
 y\text{-axis: } T \sin \theta = Xg \Rightarrow X = \frac{T \sin \theta}{g}
 \end{array}
 \quad \left| \quad \Rightarrow X = m \tan \theta
 \right.$$



### Procedure

- 1 Set up the apparatus as shown in the diagram. The long string goes through the loop of the short string. One end of the long string goes around the pulley and the mass hanger is attached to it. The other end is securely tied to the clamp of the tall stand.
- 2 Place the unknown mass  $X$  at the end of the short string. Add slot masses to the mass hanger so that the part of the string from point  $O$  to the pulley is horizontal. Then the forces are represented by the force diagram drawn at the bottom of page 1.
- 3 Use a protractor to measure the angle  $\theta$  and calculate  $\tan \theta$ . Record these values and the total mass,  $m$ .
- 4 Using these values and the equation given in the introduction, calculate the 'unknown' mass,  $X$ . Use a balance to check your result.
- 5 Repeat the process with three more 'unknown' masses.

### Questions

- 1 What changes would you have to make in your measurements if the string from point  $O$  to the pulley was not horizontal?
- 2 A ball of mass  $m$  hanging from a ceiling is pulled so that the string is at an angle  $\theta$  from the vertical and remains stationary (see diagram below). Draw the force diagram for the mass  $m$ , label the forces and resolve them into their  $x$ - and  $y$ -axes components. Calculate the force exerted by the hand.

