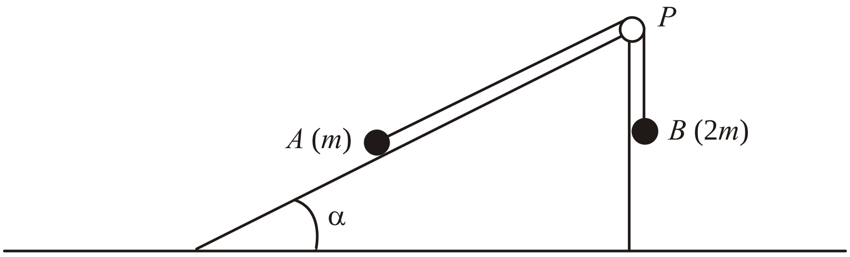
1.



Two particles A and B, of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The string passes over a small light smooth pulley P fixed at the top of the plane. The particle B hangs freely below P, as shown in the diagram above. The particles are released from rest with the string taut and the section of the string from A to P parallel to a line of greatest slope of the plane. The coefficient of friction between A and the plane is $\frac{5}{8}$. When each particle has moved a distance h, B has not reached the ground and A has not reached P.

(a) Find an expression for the potential energy lost by the system when each particle has moved a distance h.

(2)

When each particle has moved a distance h, they are moving with speed v. Using the work energy principle,

(b) find an expression for v^2, giving your answer in the form kgh, where k is a number.

(5)
(Total 7 marks)

1. (a) PE lost = $2mgh - mgh\sin\alpha$ (= $7mgh/5$) M1A1 2

(b) Normal reaction $R = mg\cos\alpha$ (= $4mg/5$) B1

Work-energy: $\frac{1}{2}mv^2 + \frac{1}{2}.2mv^2 = \frac{7mgh}{5} - \frac{5}{8}.\frac{4mg}{5}.h$ M1A2,1,0

$\Rightarrow \frac{3}{2}mv^2 = \frac{9mgh}{10} \Rightarrow v^2 = \frac{3}{5}gh$ A1 5

M1 Two term expression for PE lost. Condone sign errors and sin/cos confusion, but must be vertical distance moved for A.

A1 Both terms correct, sin α correct, but need not be simplified. Allow 13.72*mh*. Unambiguous statement.

B1 Normal reaction between A and the plane. Allow when seen in (b) provided it is clearly the normal reaction. Must use cosα but need not be substituted.

M1 (NB QUESTION SPECIFIES WORK & ENERGY) substitute into equation of the form

PE lost = Work done against friction plus KE gained. Condone sign errors. They *must include KE of both particles.*

A1A1 All three elements correct (including signs)

A1A0 Two elements correct, but followed their GPE and μx their R × *h*.

A1 V^2 correct (NB *kgh* specified in the Q)

[7]

1. Many candidates lost several marks on this question. Some simply did not attempt the question, other presented confident, but incorrect working.

(a) Many errors were made; some were simply a case of the ambiguous answer "loss of GPE $= -\frac{7mgh}{5}$", but it was also common to see both particles regarded as losing GPE, or the assumption that both particles move a vertical distance h.

(b) Some candidates clearly did not want to attempt this using work and energy. Those who did often tried to look at each particle separately rather than consider the system as a whole, and often ran into difficulties, double counting some elements. The normal reaction was usually identified correctly, leading to a correct expression for the work done against the frictional force. Two particularly common errors were the omission of the kinetic energy of B (giving an equation with $\frac{1}{2}mv^2$ rather than $\frac{3}{2}mv^2$), and double counting the increase in GPE for A.