

- 7 A smooth sphere with centre  $O$  and of radius  $a$  is fixed to a horizontal plane. A particle  $P$  of mass  $m$  is projected horizontally from the highest point of the sphere with speed  $u$ , so that it begins to move along the surface of the sphere. The particle  $P$  loses contact with the sphere at the point  $Q$  on the sphere, where  $OQ$  makes an angle  $\theta$  with the upward vertical through  $O$ .

(a) Show that  $\cos \theta = \frac{u^2 + 2ag}{3ag}$ . [4]

[illegible]

It is given that  $\cos \theta = \frac{5}{6}$ .

- (b)** Find, in terms of  $a$  and  $g$ , an expression for the vertical component of the velocity of  $P$  just before it hits the horizontal plane to which the sphere is fixed. [3]

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

- (c) Find an expression for the time taken by  $P$  to fall from  $Q$  to the plane. Give your answer in the form  $k\sqrt{\frac{a}{g}}$ , stating the value of  $k$  correct to 3 significant figures. [2]

This image shows a blank sheet of white paper with ten horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and extend across the width of the page. There is no handwriting or other markings on the paper.