Oxford Cambridge and RSA

A level Physics B

H557/02 Scientific literacy in physics

Question Set 10

1 (a) This question is about objects falling in a gravitational field.

In 1589, the Italian physicist Galileo Galilei is said to have dropped different masses from the top of the Leaning Tower of Pisa (**Fig. 1.1**) to show that all objects accelerate towards the Earth at the same rate.

Fig. 1.1

(i) The height of the Leaning Tower is 56 m.

Calculate the time for a mass to fall to the ground when released from rest at the top of the tower. Ignore the effects of air resistance.

time =……s **[2]**

(ii) Explain why two objects of different masses dropped from the top of the tower should accelerate at the same rate if air resistance is ignored.

[2]

(b) If Galileo had used two objects with very different masses, he would have observed that they did not both fall with the same acceleration. The air exerts a drag force on falling objects, decreasing their acceleration.

Taking into account the effects of drag, the acceleration a of an object falling through air at velocity v can be modelled using the equation

$$a = 9.81\ \text{m s}^{-2} - Kv^2 \quad \text{where } K \text{ is a constant for the object.}$$

(i) The motion of a falling object, taking account of drag forces, can be modelled iteratively as shown below:

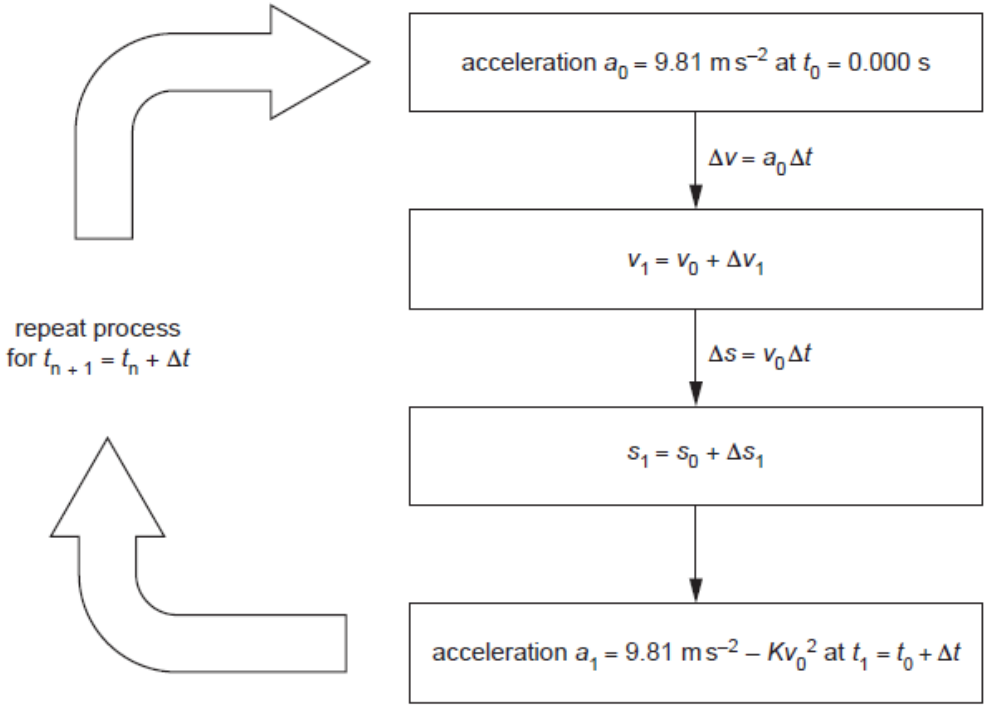

Fig. 1.2

The table below is for a ball with $K = 3.40 \times 10^{-3}\ \text{m}^{-1}$, using $\Delta t = 0.200$ s. Complete the table.

n	t/ s	a/ m s^{-2}	Δv/ m s^{-1}	v/ m s^{-1}	Δs/ m	s/ m
0	0.000	9.81	–	0.00	–	0.00
1	0.200	9.81	1.96	1.96	0.00	0.00
2	0.400					

[3]

(ii)* Further iterations of the calculation produce the graph in **Fig. 1.3**.

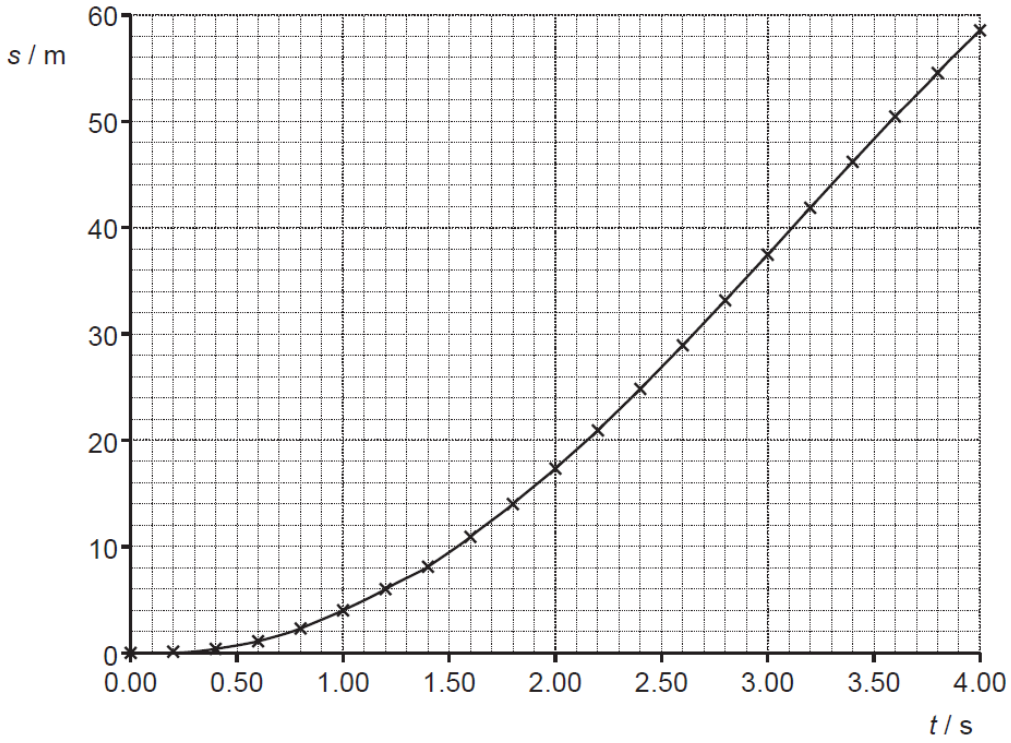

Fig. 1.3

Use data from the graph to estimate the time for this ball to fall from the top of the Leaning Tower to the ground.

Explain why the model may not give an accurate result and how the model could be improved.

Compare your estimate with your value from **(a)(i)** and use this to suggest and explain whether observers in 1589 would have been able to distinguish between the time of fall of relatively similar masses from the top of the tower.

[6]

Total Marks for Question Set 10: