4 A roller coaster car of mass 380 kg at rest slides down a smooth slope and executes a smooth loop of diameter *d*. After the loop, it experiences friction only in the area denoted as zone A, as shown in Fig. 4.1. Ignore air resistance.

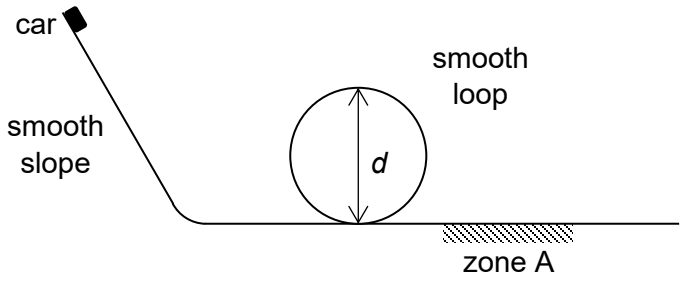

Fig. 4.1

The variation of gravitational potential energy and total mechanical energy of the car with time *t* are shown in Fig. 4.2.

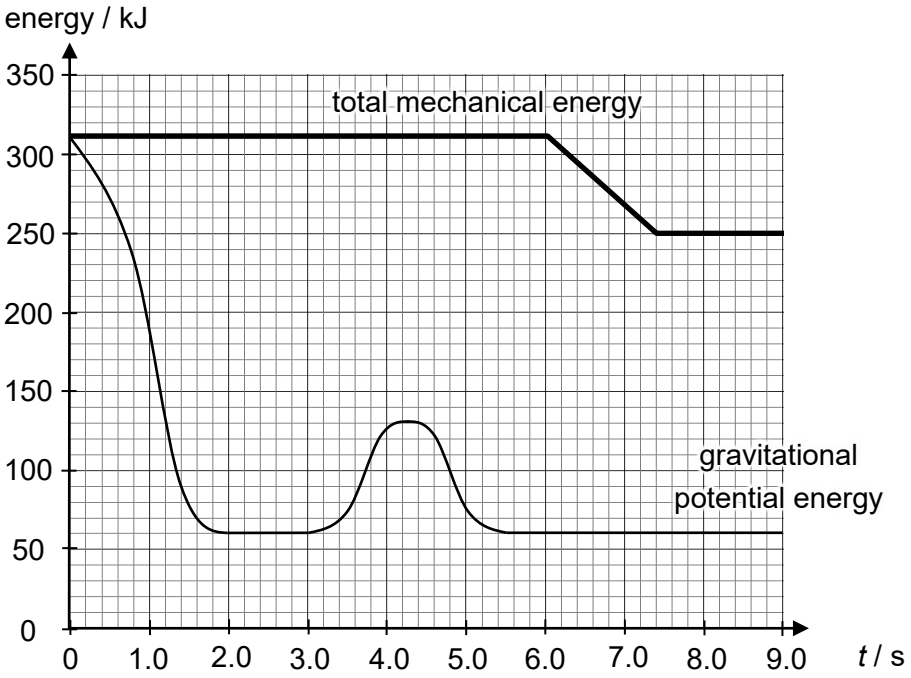

Fig. 4.2

(a) **(i)** On Fig. 4.2, sketch the variation with time of the kinetic energy of the car, from *t* = 0 s to *t* = 9.0 s. [2]

(ii) Between $t = 3.0$ s and $t = 5.4$ s, the car executes the loop.

Using Fig. 4.2, calculate d.

d = ... m [2]

(iii) Using answers from **(i)** and **(ii)**, determine the contact force on the roller coaster at the top of the loop.

contact force = ... N [2]

(b) **(i)** By considering the start and end times when the car in within zone A, calculate the average rate at which the car loses energy in zone A.

rate = ... W [2]

(ii) Given that the average speed of the roller coaster in Zone A is 34.0 m s^{-1}, calculate the average frictional force acting on the car in zone A.

frictional force = N [2]