Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

5 Newton's laws of motion

Exercise B, Question 14

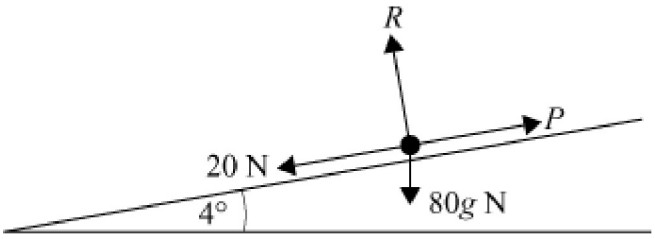
Question:

A cyclist travels up a slope inclined at 4° to the horizontal. The cyclist and cycle are modelled as a particle of mass 80 kg. A constant air resistance force of magnitude 20 N acts throughout the motion. The diagram shows the forces that are assumed to act on the particle.

(a) Find the value of P:
(i) when the cyclist moves at a constant speed,
(ii) when the cyclist accelerates at 0.2 m s^{-2}.
The cyclist accelerates at 0.2 m s^{-2} from rest until her speed reaches 4 m s^{-1}. She then travels at a constant speed.

(b) (i) Find the time for which the cyclist accelerates.
(ii) Sketch a velocity-time graph for the motion of the cyclist.

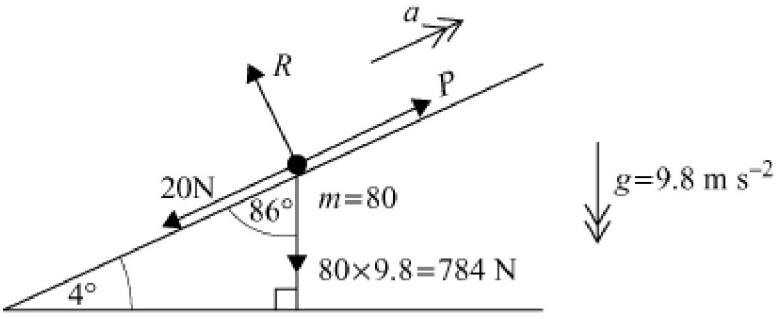
(c) (i) Explain why modelling the air resistance as a constant might not be appropriate.
(ii) Sketch a velocity-time graph to show how a more realistic air resistance would affect the motion of the cyclist. [A]



Solution:

(a) (i) At constant speed, resultant acceleration is zero
Newton's 2nd Law up slope

$$P - 20 - 784\cos 86° = 80 \times 0$$
$$\therefore P = 20 + 784\cos 86°$$
$$P = 74.689...$$
$$P = 74.7 \text{ N (3 s.f.)}$$



(ii) when $a = 0.2$ m s^{-2},

Newton's 2nd Law up slope

$P - 20 - 784 \cos 86° = 80 \times 0.2$

$\therefore P = 20 + 784 \cos 86° + 80 \times 0.2$

$P = 90.689...$

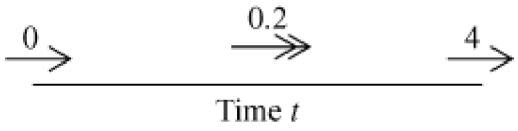
$P = 90.7$ N (3 s.f.)

$v = u + at$

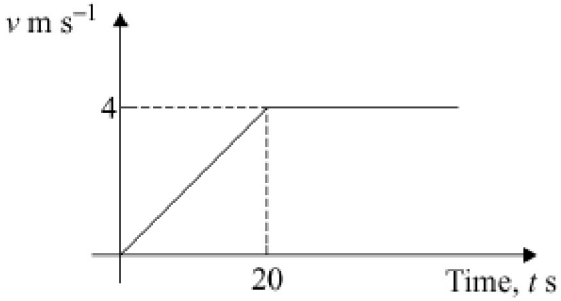
$4 = 0 + 0.2 \times t$

(b) (i) $\therefore t = \frac{4}{0.2}$

$t = 20$ seconds



(ii)



(c) (i) As the speed increases, air resistance increases.

(ii)