Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

5 Newton's laws of motion

Exercise A, Question 9

Question:

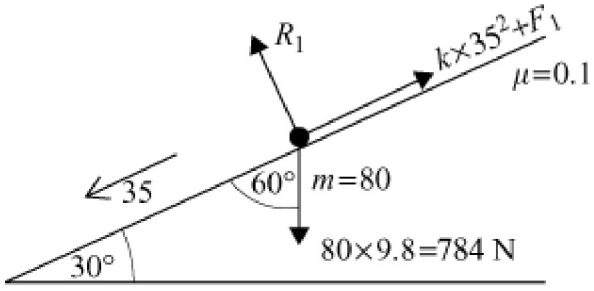
A skier of mass 80 kg can achieve a maximum speed of 35 m s^{-1} down an incline at an angle of 30° to the horizontal, subject to: air resistance which is proportional to her speed; and friction where the coefficient of friction between skier and the slope is 0.1. What will be the maximum speed of the skier down a slope inclined at an angle of 45° to the horizontal?

Solution:

Newton 1, down slope

$$784 \cos 60° - k \times 35^2 - F_1 = 0$$

$$F_1 = 784 \cos 60° - k \times 35^2$$



Newton 1, perpendicular to slope

$$R_1 - 784 \sin 60° = 0$$

$$R_1 = 784 \sin 60°$$

$$R_1 = 678.96 \text{ N}$$

Limiting friction

$$F_1 = 0.1 \times R_1$$

$$F_1 = 0.1 \times 678.96$$

$$= 67.896 \text{ N}$$

$$\therefore 67.896 = 784 \cos 60° - k \times 35^2 \text{ (see 1st equation above)}$$

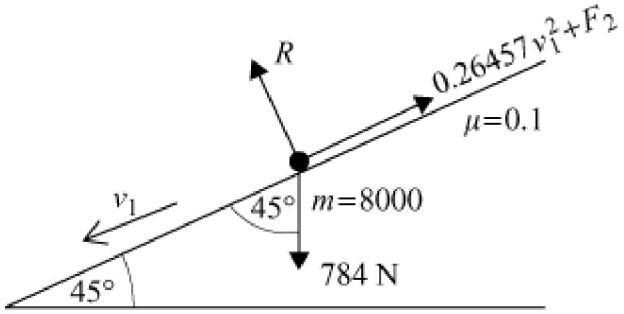
$$k = \frac{784 \cos 60° - 67.896}{35^2}$$

$$k = 0.26457...$$

Newton 1, down slope

$784 \cos 45° - 0.26457v_1^2 - F_2 = 0$

$F_2 = 784 \cos 45° - 0.26457v_1^2$



Newton 1, perpendicular to slope

$R_2 - 784 \sin 45° = 0$

$R_2 = 554.37$

Limiting friction

$F_2 = 0.1 \times R_2$

$F_2 = 0.1 \times 554.37$

$F_2 = 55.437$

$\therefore 55.437 = 784 \cos 45° - 0.26457v_1^2$ (see above for "down slope")

$v_1^2 = \frac{784 \cos 45° - 55.437}{0.26457}$

$v_1^2 = 1885.8$

$v_1 = 43.425...$

$v_1 = 43.4$ (3 s.f.)