Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

5 Newton's laws of motion

Exercise B, Question 22

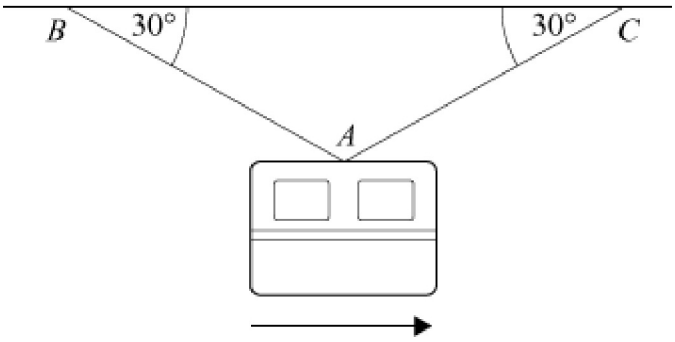
Question:

Two cables, *AB* and *AC*, are attached to a cable car, as shown in the diagram. The cable car has mass 450 kg. The cable car travels horizontally in the direction shown by the arrow. Model the cable car as a particle and assume that there is no air resistance present. As the cable car moves, the angles shown in the diagram do not change.

(a) The cable car travels at a constant speed. Show that the tension in each cable is 4410 N.

(b) The cable car now accelerates in the direction of the arrow at 0.5 m s^{-2}. Find the tension in each cable.

(c) Describe how your answers to (b) would change if air resistance was taken into account. [A]



Solution:

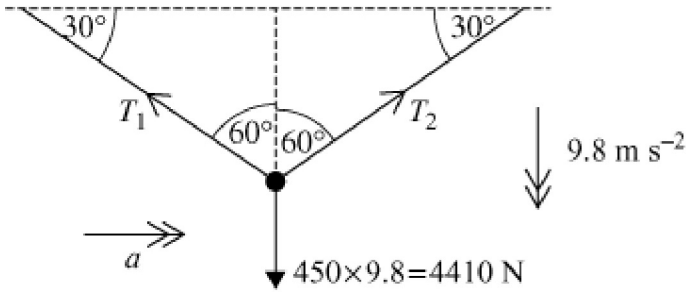
(a) when $a = 0$
Newton's 2nd Law, →

$$T_2 \sin 60° - T_1 \sin 60° = 450 \times 0$$
$$\therefore T_2 \sin 60° = T_1 \sin 60°$$
$$\therefore T_2 = T_1$$

Newton's 2nd Law, ↑

$$T_1 \cos 60° + T_2 \cos 60° - 4410 = 450 \times 0 \text{, but } T_2 = T_1$$
$$\therefore T_1 \times 0.5 + T_1 \times 0.5 = 4410$$
$$\therefore T_1 = 4410 \text{ N and } \therefore T_2 = 4410 \text{ N}$$

$\therefore$ tension in both cables is 4410 N



(b) when $a = 0.5$

Newton's 2nd Law, $\rightarrow$ $T_2 \sin 60° - T_1 \sin 60° = 450 \times 0.5$ $\{ \div \sin 60°$

Newton's 2nd Law, $\uparrow$ $T_2 \cos 60° + T_1 \cos 60° - 4410 = 450 \times 0$ $\{ \div \cos 60°$

$$\therefore T_2 - T_1 = \frac{450 \times 0.5}{\sin 60°}$$
$$T_2 + T_1 = \frac{4410}{\cos 60°}$$

$$\therefore \text{adding } 2T_2 = \frac{450 \times 0.5}{\sin 60°} + \frac{4410}{\cos 60°}$$

$$\therefore T_2 = \frac{1}{2}\left[\frac{450 \times 0.5}{\sin 60°} + \frac{4410}{\cos 60°}\right]$$

$T_2 = 4539.90...$

$T_2 = 4540$ N (3 s.f.)

Then $T_1 = \frac{4410}{\cos 60°} - 4539.90...$

$T_1 = 4280.09...$

$T_1 = 4280$ N (3 s.f.)

(c) T_2 would increase to overcome the resistance.
T_1 would decrease since it is aided by the resistance.