

Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

5 Newton's laws of motion

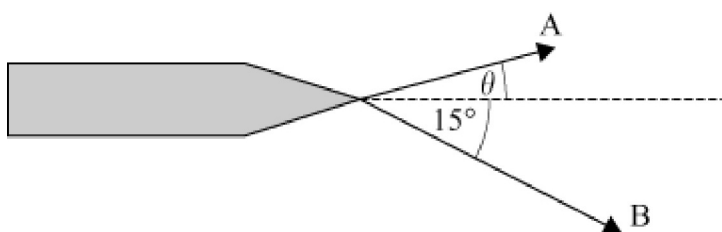
Exercise B, Question 17

Question:

Two tugs are towing a large oil tanker into harbour. Tug A's engines can produce a pulling force of 80 kN while tug B's engines can produce 65 kN of force.

(a) Calculate the angle θ necessary for the tanker to move directly forwards.

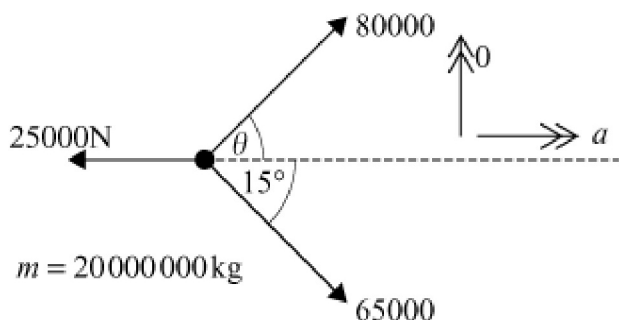
(b) Given that there is a resistance to the motion of the tanker of 25 kN directly opposing motion, find the magnitude of the resultant force on the tanker to the nearest 1000 N. Find also the acceleration of the tanker if it has a mass of 20 000 tonnes.



Solution:

(a) Newton's 2nd Law perpendicular to the velocity:

$$\begin{aligned}
 80000 \sin \theta - 65000 \sin 15^\circ &= m \times 0 \\
 \therefore 80000 \sin \theta &= 65000 \times \sin 15^\circ \\
 \therefore \sin \theta &= \frac{65000 \times \sin 15^\circ}{80000} \\
 \theta &= 12.139\dots \\
 \theta &= 12.1^\circ \text{ (3 s.f.)}
 \end{aligned}$$



(b) Resultant force in direction of motion

$$\begin{aligned}
 &= 80000 \cos \theta + 65000 \cos 15^\circ - 25000 \\
 &= 80000 \cos 12.139^\circ + 65000 \cos 15^\circ - 25000 \\
 &= 115996.40\dots \\
 &= 116000 \text{ N (nearest 1000 N)}
 \end{aligned}$$

then Newton's 2nd Law in this direction

$$115996.29\dots = 20000000 \times a$$

$$\therefore a = \frac{115996.29}{20000000}$$

$$a = 0.0057998\dots$$

$$a = 0.00580 \text{ m s}^{-2} \text{ (3 s.f.)}$$

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