

Exercise walk-through

5.3

Newton's laws and friction

Pearson Edexcel · International A-Level · Mathematics

Check yourself

Check yourself

State modelling assumptions and their consequences; vector velocities, positions, bearings; multi-phase suvat and motion graphs; paired equations over a pulley with the 2T pulley force; impulse on one body and momentum conservation with rebounds; μR moving versus capped at rest; equilibrium by two resolutions; moments about successive tilting pivots.

Exercises 2.1·2.3

2.1 A 4 kg block slides on a smooth horizontal surface under a 20 N horizontal force. Find its acceleration and the normal reaction. [3]

2.2 The surface is now rough with $\mu = 0.25$. Find the acceleration under the same 20 N force. [4]

2.3 A person of mass 80 kg stands in a lift accelerating upwards at 1.5 m s^{-2} . Find the normal reaction from the lift floor. [4]

Exercises 2.1·2.3

2.1 A 4 kg block slides on a smooth horizontal surface under a 20 N horizontal force. Find its acceleration and the normal reaction. [3]

$$\mathbf{2.1} \quad a = \frac{20}{4} = 5 \text{ m s}^{-2}; R = 4g = 39.2 \text{ N}.$$

2.2 The surface is now rough with $\mu = 0.25$. Find the acceleration under the same 20 N force. [4]

$$\mathbf{2.2} \quad R = 39.2 \text{ N, friction} = 0.25(39.2) = 9.8 \text{ N}; a = \frac{20 - 9.8}{4} = 2.55 \text{ m s}^{-2} \text{ (2.6).}$$

2.3 A person of mass 80 kg stands in a lift accelerating upwards at 1.5 m s^{-2} . Find the normal reaction from the lift floor. [4]

$$\mathbf{2.3} \quad R - 80g = 80(1.5), \text{ so } R = 80(9.8 + 1.5) = 904 \text{ N}.$$

Exercises 2.4·3.1

2.4 An 8 kg crate on rough horizontal ground ($\mu = 0.4$) is pulled by a rope at 30° above the horizontal with tension 50 N. Find its acceleration. [4]

3.1 (*Edexcel IAL WME01 June 2025 Q4.*) Two ropes are attached to a point on the front of a barge of mass 15 tonnes. The barge is pulled along a straight canal by a horizontal force of 800 N acting at 25° to the direction of motion and a horizontal force of 500 N acting at α° to the direction of motion, on the other side of it. The barge accelerates along the canal, and the total resistance to motion is 750 N. (a) Find α . (b) Find the acceleration of the barge. [7]

Exercises 2.4·3.1

2.4 An 8 kg crate on rough horizontal ground ($\mu = 0.4$) is pulled by a rope at 30° above the horizontal with tension 50 N. Find its acceleration. [4]

2.4 Perpendicular: $R = 8g - 50 \sin 30^\circ = 78.4 - 25 = 53.4$ N. Friction $= 0.4(53.4) = 21.36$ N. Along: $50 \cos 30^\circ - 21.36 = 8a$, so $a = \frac{43.30 - 21.36}{8} = 2.74 \text{ m s}^{-2}$ (2.7).

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3.1 (a) No acceleration perpendicular to the canal: $800 \sin 25^\circ = 500 \sin \alpha$, so $\sin \alpha = \frac{800(0.4226)}{500} = 0.676$ and $\alpha = 43^\circ$ (nearest degree). (b) Along the canal: $800 \cos 25^\circ + 500 \cos 42.55^\circ - 750 = 15000a$: $725.0 + 368.1 - 750 = 343.1 = 15000a$, so $a = 0.023 \text{ m s}^{-2}$.

Exercise 3.2

3.2 (*Edexcel IAL WME01 June 2025 Q6c.*) A package of mass 2 kg is held at rest on a rough plane inclined at θ to the horizontal, where $\tan \theta = \frac{3}{4}$, by a force of X N directed up the plane along a line of greatest slope. The coefficient of friction between the package and the plane is $\frac{1}{4}$. Find the smallest possible value of X . [3]

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3.2 Least X when friction acts UP the slope at its limit (helping hold the package).
 Perpendicular: $R = 2g \cos \theta = 2(9.8)(\frac{4}{5}) = 15.68$ N; friction $= \frac{1}{4}(15.68) = 3.92$ N. Along:
 $X = 2g \sin \theta - 3.92 = 2(9.8)(\frac{3}{5}) - 3.92 = 11.76 - 3.92 = 7.84$ N ($= \frac{4}{5}g$).

Local review guidance: resolution both perpendicular and along, all terms present and signed; friction μR only once R is found; answers to 2–3 s.f. with units, or as exact multiples of g when the question says "show". This is authored classroom guidance.