Newton's Laws of Motion

Cambridge International AS & A Level - Mathematics 9709
Paper 4: Mechanics - Exam-style question bank

Original Steps to Conquer practice questions in the style of recent 9709 Paper 4 examinations - not past Cambridge questions. Marks are shown in brackets [ ]. Give non-exact answers to 3 significant figures (1 d.p. for angles) and show full working.

Questions

1 A particle of mass 5 kg is pulled along a smooth horizontal surface by a horizontal force of 30 N. Find its acceleration. [3]

2 A particle of mass 4 kg is pulled along a horizontal surface by a force of 30 N. A constant resistance of 6 N acts against the motion. Find the acceleration. [4]

3 A person of mass 70 kg stands in a lift accelerating upwards at 2 m s^{-2}. Find the normal reaction exerted by the lift floor on the person. [4]

4 A particle slides down a smooth plane inclined at 30° to the horizontal. Find its acceleration. [4]

5 A particle of mass 5 kg is pulled up a rough plane inclined at 30° by a force of 60 N acting up the plane. The coefficient of friction is 0.2. Find its acceleration. [6]

6 Two particles of masses 3 kg and 2 kg are connected by a light inextensible string passing over a smooth pulley. Find the acceleration and the tension in the string. [6]

7 A car of mass 800 kg tows a trailer of mass 200 kg along a horizontal road. The driving force is 1500 N. The total resistance is 500 N, of which 100 N acts on the trailer. Find the acceleration and the tension in the tow-bar. [7]

8 Two blocks of masses 3 kg and 5 kg are connected by a light string on a smooth horizontal surface. A horizontal force of 40 N is applied to the 5 kg block. Find the acceleration and the tension in the string. [6]

9 A particle of mass 2 kg moves down a rough plane inclined at 30°. The coefficient of friction is 0.25. Find its acceleration. [6]

10 A particle of mass 6 kg is pulled vertically upwards by a force of 90 N. Find its acceleration. [4]

Worked solutions

Full methods with final answers. Other valid methods may also earn full marks.

1 Using $F = ma$, $30 = 5a$.
$a = 6$ m s^{-2}.

2 Resultant force $= 30 - 6 = 24$ N.
$24 = 4a$, so $a = 6$ m s^{-2}.

3 For the person, $R - 70g = 70(2)$.
Using $g = 10$, $R - 700 = 140$.
$R = 840$ N.

4 The component of weight down the plane is $mg\sin 30°$.
$ma = mg\sin 30°$.
$a = 10\sin 30° = 5$ m s^{-2}.

5 $R = 5g\cos 30° = 50\cos 30°$.
Friction $= 0.2R = 10\cos 30°$.
The component of weight down the plane is $50\sin 30° = 25$ N.
Resultant up the plane $= 60 - 25 - 10\cos 30° = 26.34$ N.
$5a = 26.34$, so $a = 5.27$ m s^{-2}.

6 The driving force is $(3 - 2)g = 10$ N.
Total mass $= 5$ kg, so $a = \frac{10}{5} = 2$ m s^{-2}.
For the 3 kg mass moving downwards, $30 - T = 3(2)$.
$T = 24$ N.

7 For the whole system, resultant force $= 1500 - 500 = 1000$ N.
Total mass $= 1000$ kg, so $a = 1$ m s^{-2}.
For the trailer, $T - 100 = 200(1)$.
$T = 300$ N.

8 For the two blocks together, $40 = (3 + 5)a$.
$a = 5$ m s^{-2}.
For the 3 kg block, the only horizontal force is the tension.
$T = 3(5) = 15$ N.

9 Component of weight down the plane $= 20\sin 30° = 10$ N.
$R = 20\cos 30°$.
Friction $= 0.25R = 5\cos 30° = 4.33$ N.
Resultant down the plane $= 10 - 4.33 = 5.67$ N.
$2a = 5.67$, so $a = 2.84$ m s^{-2}.

10 Weight $= 6g = 60$ N.
Resultant upward force $= 90 - 60 = 30$ N.

$30 = 6a$, so $a = 5$ m s^{-2}.