

Forces, friction and motion on slopes

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Marks are given for the correct equation, substitution and answer with units. Follow-through marks apply when an earlier error is carried into a later part correctly. The marking notes show where each mark is earned.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB A.2

Question 1 Newton's second law (1 mark)

$\Sigma F = ma$, where ΣF is the resultant force, m the mass and a the acceleration.

Marking: 1 mark for the equation with symbols defined.

Question 2 Friction and direction (2 marks)

Friction acts **opposite to the sliding direction**. Static friction adjusts to equal the applied push, up to a limit, so while the box is not moving it is only as large as needed.

Marking: 1 mark for direction; 1 mark for static friction matching the push.

Question 3 Pushed crate (3 marks)

a. $f = 0.25 \times 30 \times 9.81 = \mathbf{73.6\ N}$.

b. Resultant = $150 - 73.6 = 76.4\ \text{N}$; $a = 76.4 \div 30 = \mathbf{2.5\ m/s^2}$.

Marking: (a) 1 mark; (b) 1 mark for the resultant, 1 mark for the acceleration.

Question 4 Block on a slope (4 marks)

a. $mg \sin 35^\circ = 58.86 \times 0.5736 = \mathbf{33.8\ N}$.

b. $N = mg \cos 35^\circ = 58.86 \times 0.8192 = \mathbf{48.2\ N}$.

c. $f = 0.30 \times 48.2 = \mathbf{14.5\ N}$.

d. $a = (33.8 - 14.5) \div 6.0 = \mathbf{3.2\ m/s^2}$.

Marking: 1 mark for each part.

Question 5 Joined trolleys (3 marks)

a. $a = 15 \div (4.0 + 1.0) = \mathbf{3.0\ m/s^2}$.

b. The string accelerates only the 1.0 kg trolley: $T = 1.0 \times 3.0 = \mathbf{3.0\ N}$.

c. The string is taut and does not stretch, so the trolleys **move together**.

Marking: 1 mark for each part.

Question 6 Lift passenger (3 marks)

a. $mg - N = ma$, so $N = 60 \times (9.81 - 2.0) = \mathbf{469\text{ N}}$.

b. $N = mg = 60 \times 9.81 = \mathbf{589\text{ N}}$.

Marking: (a) 1 mark for the equation, 1 for the answer; (b) 1 mark.

Question 7 Static and kinetic (2 marks)

With locked wheels the tyres slide, so the smaller **kinetic friction** acts. With gradual braking the tyres roll without slipping, so the larger **static friction** up to $\mu_s N$ is available.

Marking: 1 mark for kinetic friction on sliding tyres; 1 mark for the larger static friction.

Question 8 Normal reaction on a slope (2 marks)

The weight acts vertically, but the surface only has to balance the component **perpendicular to the slope**, $mg \cos \theta$. The component along the slope, $mg \sin \theta$, is not balanced by the normal reaction, so $N = mg \cos \theta$ is less than mg .

Marking: 1 mark for the perpendicular component; 1 mark for $N = mg \cos \theta$.