

Newton's Law of Motion

Question Paper

Level	Pre U
Subject	Maths
Exam Board	Cambridge International Examinations
Topic	Mechanics- Newton's Law of Motion
Booklet	Question Paper

Time Allowed: 65 minutes

Score: /54

Percentage: /100

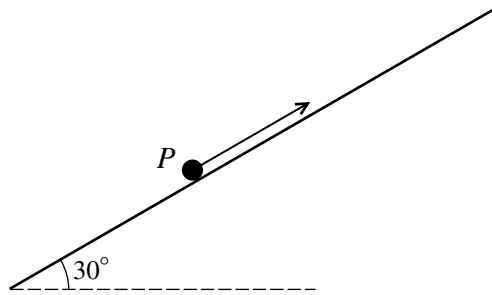
Grade Boundaries:

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- 1** A particle of mass m is placed on a rough inclined plane. The plane makes an angle θ with the horizontal. The coefficient of friction between the particle and the plane is μ where $\mu < \tan \theta$. The particle is released from rest and accelerates down the plane.
- (i) Draw a fully labelled diagram to show the forces acting on the particle. [1]
 - (ii) Find an expression in terms of g , θ and μ for the acceleration of the particle. [5]
 - (iii) Explain what would happen to the particle if $\mu > \tan \theta$. [1]
- 2** A light inextensible string passes over a smooth fixed pulley. Particles of mass 0.2 kg and 0.3 kg are attached to opposite ends of the string, so that the parts of the string not in contact with the pulley are vertical. The system is released from rest with the string taut.
- (i) Find the acceleration of the particles and the tension in the string. [6]
- When the heavier particle has fallen 2.25 m it hits the ground and is brought to rest (and the string goes slack).
- (ii) Find the speed with which it hits the ground. [2]
 - (iii) Find the magnitude of the impulse of the ground on the particle. [2]
 - (iv) If the impact between the particle and the ground lasts for 0.005 seconds, find the constant force that would be needed to bring the particle to rest. [2]
- 3** A crane lifts a crate of mass 20 kg using a light inextensible cable. The crate starts from rest and ascends 10 metres in 4 seconds during which time a constant tension of T N is applied in the cable. Find the value of T . [4]

4



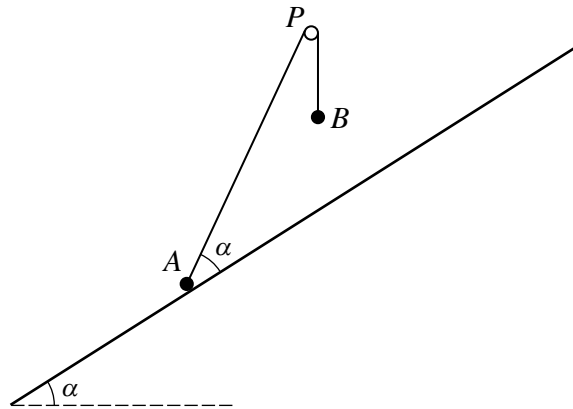
A particle P of mass 2 kg can move along a line of greatest slope on a smooth plane, inclined at 30° to the horizontal. P is initially at rest at a point on the plane, and a force of constant magnitude 20 N is applied to P parallel to and up the slope (see diagram).

- (i) Copy and complete the diagram, showing all forces acting on P . [1]
- (ii) Find the velocity of P in terms of time t seconds, whilst the force of 20 N is applied. [4]

After 3 seconds the force is removed at the instant that P collides with a particle of mass 1 kg moving down the slope with speed 5 m s^{-1} . The coefficient of restitution between the particles is 0.2 .

- (iii) Express the velocity of P as a function of time after the collision. [6]

5



Particles A and B of masses $2m$ and m , respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley P . The particle A rests in equilibrium on a rough plane inclined at an angle α to the horizontal, where $\alpha \leq 45^\circ$ and B is above the plane. The vertical plane defined by APB contains a line of greatest slope of the plane, and PA is inclined at angle 2α to the horizontal (see diagram).

(i) Show that the normal reaction R between A and the plane is $mg(2 \cos \alpha - \sin \alpha)$. [3]

(ii) Show that $R \geq \frac{1}{2}mg\sqrt{2}$. [3]

The coefficient of friction between A and the plane is μ . The particle A is about to slip down the plane.

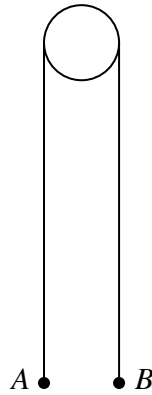
(iii) Show that $0.5 < \tan \alpha \leq 1$. [3]

(iv) Express μ as a function of $\tan \alpha$ and deduce its maximum value as α varies. [3]

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- 6 A light inextensible string passes over a fixed smooth light pulley. Particles A and B , of masses 2 kg and 3 kg respectively, are attached to the ends so that the portions of the string below the axis of the pulley are vertical (see diagram). The centre of the horizontal axis of the pulley is 4 m above ground level.



The particles are released from rest 1 m above ground level with the string taut.

- (i) Determine the acceleration of both particles prior to the impact of B with the ground. [3]
- (ii) Determine the greatest height attained by A above ground level. [3]
- (iii) If B rebounds after impact to a first maximum height of 0.05 m, determine the coefficient of restitution between B and the ground. [2]