Section 2: Newton's second law

Exercise level 2

1. A particle of mass 2 kg rests on a plane inclined at 30° to the horizontal. The particle is connected to a mass of 3.5 kg by a light inextensible string passing over a smooth pulley at the top of the plane. The 3.5 kg mass hangs freely. Find the acceleration of the system and the tension in the string when the system is released from rest.

2. A disc of mass 5 kg is projected up a smooth plane inclined at an angle of θ to the horizontal, where $\sin\theta = \frac{1}{5}$. The disc is given an initial velocity of 7 ms^{-1}. How far up the plane will the disc move before coming to rest?

3. A car of mass 1200 kg pulls a trailer of mass 500 kg up a road inclined at an angle of θ to the horizontal, where $\sin\theta = 0.1$. The resistance to motion for both car and trailer is 0.15 N per kg. Find the tractive force developed by the engine and the tension in the coupling if the car and trailer are
   a) travelling at constant speed,
   b) decelerating at ½ ms^{-2}.

4. A slide consists of a sloping section followed by a straight section. Both sections are 5 m long. The sloping section is inclined at an angle α to the horizontal such that $\sin\alpha = \frac{5}{13}$. A girl of mass 30 kg starts from rest from the top of the sloping section and is subject to a constant resistance of 50 N along both the sloping and straight sections. Calculate
   (i) the acceleration down the slope
   (ii) the speed at the bottom of the slope
   (iii) the deceleration on the straight section
   (iv) the speed at the end of the straight section

5. A tile of mass 3 kg slides 2 m from rest down a roof inclined at an angle of 30° to the horizontal against a resistance of 7 N. The edge of the roof is 3.5 m above the ground. Find
   (i) The acceleration of the tile down the roof
   (ii) The velocity of the tile at the edge of the roof
   (iii) The time taken for the tile to hit the ground
   (iv) The horizontal distance from the edge of the roof to the point where the tile lands.

6. A crate of weight 275 N is pulled up a smooth plane inclined at 45° to the horizontal by a light inextensible rope which is parallel to the slope. The crate is accelerating at 0.8 ms^{-2}. Find the tension in the rope.

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7. A particle of mass m rests on a smooth plane inclined at an angle of α to the horizontal. It is connected by a light inextensible string passing over a smooth pulley at the top of the plane to a mass M which hangs freely.
   (i) find the condition on α for which the mass m is on the point of sliding down the plane when the system is released from rest
   (ii) find the condition on α for which m moves up the plane with an acceleration of 0.5 ms^{-2}.

8. A car of mass 1200 kg pulls a trailer of mass 300 kg. The car experiences a resistance of 400 N to motion and the trailer experiences a resistance of 100 N to motion. The engine of the car produces a constant driving force so that the system accelerates at $\frac{4}{3}$ ms^{-2}. Find the driving force and the tension in the tow bar when
   (i) The car and trailer are accelerating UP a hill inclined at 2° to the horizontal,
   (ii) The car and trailer are accelerating DOWN the same hill.

9. An engine of mass 20 tonnes pulls two trucks each of mass 10 tonnes along a horizontal track. The engine is subject to a resistance of 800 N and each truck subject to a resistance of 500 N.
   (i) Find the driving force of the engine if the train is travelling at a constant speed.
   (ii) Find the force in each of the couplings.

   The train now comes to an incline of 10° to the horizontal and starts to ascend.
   (iii) If the engine maintains the same driving force, calculate the deceleration of the train and the forces that now exist in the couplings.