Higher Forces at Angles Questions

1. A **500g block** held at a height of **1.6m** is released from rest on a **friction compensated slope**.

Calculate the velocity of the block at the **bottom of the slope**.

2. A **1.4kg block** is released from rest at a height of **1.75m** down an inclined slope of **length 2m**.

If the block reaches a velocity of **4.78ms^{-1}** at the bottom of the slope, then **calculate the force of friction** acting on the block down the slope.

3. What are the equations for the **component of weight** acting:

a) **Parallel** to an inclined slope.

b) **Perpendicular** to an inclined slope.

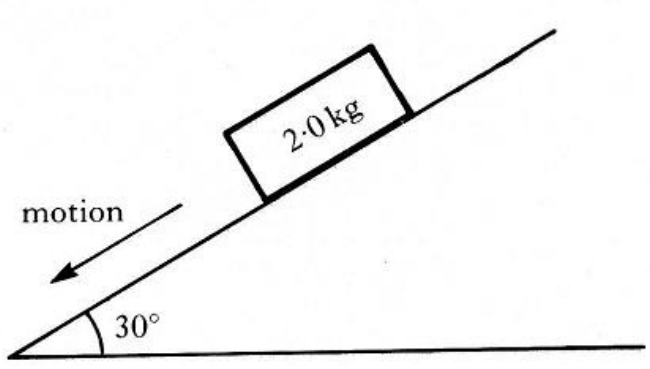
4. An object of mass **2.6kg** is acting down an inclined plane at **30^{o}** to the horizontal.

If the **force of friction** acting against the motion of the object of **4.94N**, then calculate or find:

a) **Unbalanced force** on the object acting down the slope.
b) **Acceleration** of the object down the slope.

5. A block of wood of mass **2.0kg** slides with a **constant velocity** down a slope.

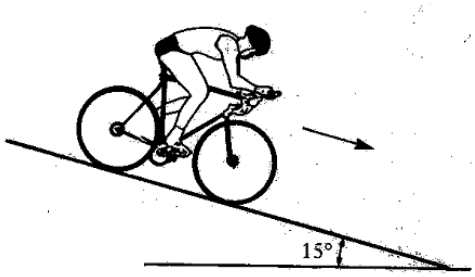
The slope makes an angle of **30° with the horizontal** as shown in the diagram below.



Calculate the **force of friction** acting on the block of wood.

6. A cyclist free-wheels down a slope inclined at an angle of 15° to the horizontal.

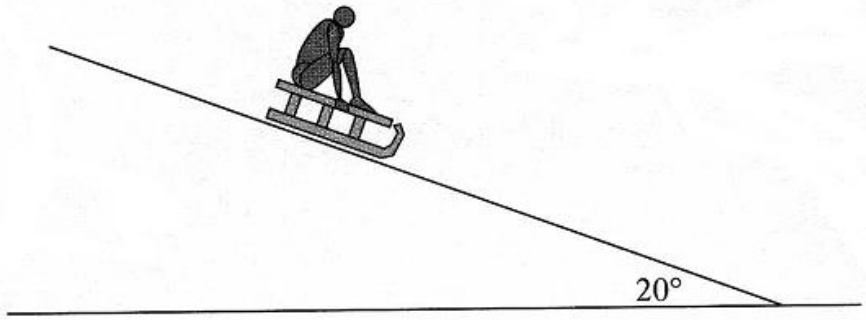
The combined mass of the rider and bicycle is **80kg**.



Calculate the **total force of friction** if the rider and bicycle move with a **constant speed** of 4ms^{-1}.

7.

A child on a sledge slides down a slope which is at an angle of 20° to the horizontal as shown below.



The combined weight of the child and the sledge is 400 N. The frictional force acting on the sledge and child at the start of the slide is 20·0 N.

(*a*) (i) Calculate the component of the combined weight of the child and sledge down the slope.

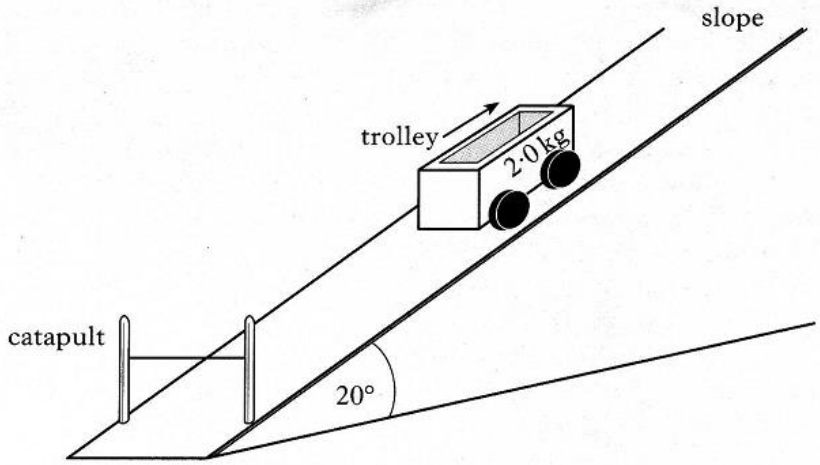
(ii) Calculate the initial acceleration of the sledge and child.

(*b*) The child decides to start the slide from further up the slope. Explain whether or not this has any effect on the initial acceleration.

(*c*) During the slide, the sledge does not continue to accelerate but reaches a constant speed. Explain why this happens.

8.

A trolley of mass 2·0 kg is catapulted up a slope. The slope is at an angle of 20° to the horizontal as shown in the diagram below. The speed of the trolley when it loses contact with the catapult is 3·0 m s^{-1}.



The size of the force of friction acting on the trolley as it moves up the slope is 1·3 N.

(*a*) (i) Calculate the component of the weight of the trolley acting parallel to the slope.

(ii) Draw a diagram to show the forces acting on the trolley as it moves **up the slope** and is no longer in contact with the catapult.

Show only forces or components of forces acting parallel to the slope. Name the forces.

(iii) Show that, as the trolley moves up the slope, it has a deceleration of magnitude 4·0 m s^{-2}.

(iv) Calculate the time taken for the trolley to reach its furthest point up the slope.

(v) Calculate the maximum distance the trolley travels along the slope.

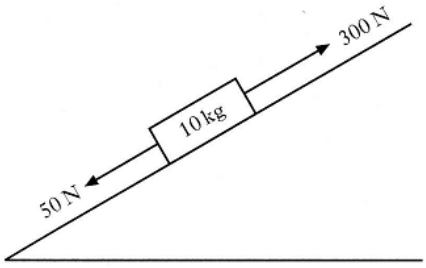
The trolley now moves back down the slope.

(*b*) (i) Draw a diagram to show the forces acting on the trolley as it moves **down the slope**.

Show only forces or components of forces acting parallel to the slope. Name the forces.

(ii) The magnitude of the deceleration of the trolley is 4·0 m s^{-2} as it moves up the slope. Explain why the magnitude of the acceleration is not 4·0 m s^{-2} when the trolley moves down the slope.

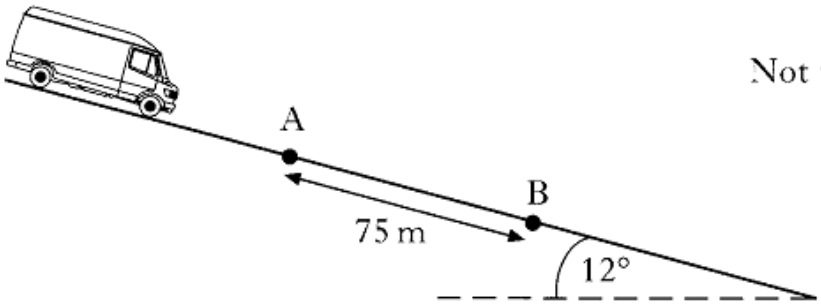
9. A box of mass **10kg** rests on an inclined plane. The component of weight of the box acting down the plane is **50N** and a force of **300N** is applied parallel to the plane as shown below.



Calculate the frictional force opposing the motion if the box accelerates at **8ms^{-2}** up the slope.

10.

A van of mass 2600 kg moves down a slope which is inclined at 12° to the horizontal as shown.



(*a*) Calculate the component of the van's weight parallel to the slope.

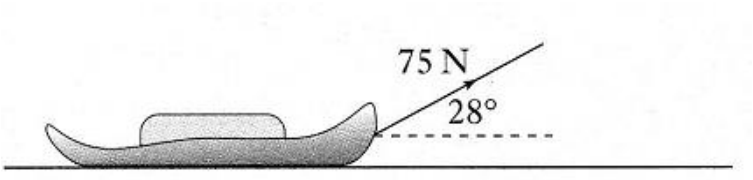
(*b*) A constant frictional force of 1400 N acts on the van as it moves down the slope.

Calculate the acceleration of the van.

(*c*) The speed of the van as it passes point **A** is $5{\cdot}0\,\text{m s}^{-1}$.
Point **B** is 75 m further down the slope.

Calculate the kinetic energy of the van at **B**.

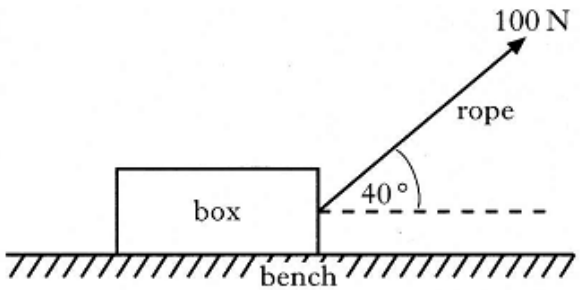
11. A sledge is pulled a **distance of 8m** in a straight line along a horizontal surface.



Calculate or find:

a) **Horizontal** component of **tension** in the rope.
b) **Vertica**l component of **tension** in the rope.
c) **Work Done** by the rope on the sledge.

12. A box is pulled along a level bench by a rope held at a constant angle of **40° to the horizontal**.

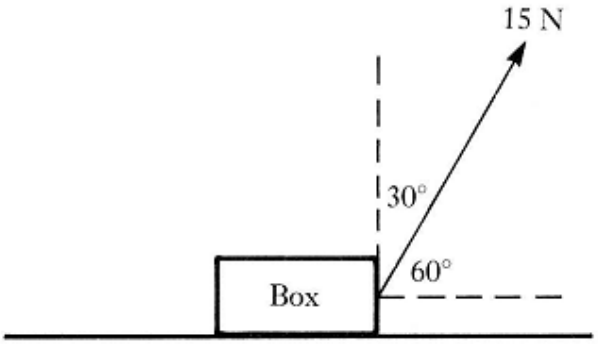


A constant force of **100N is applied** to the rope and it moves a distance **10m** along the bench.

Calculate the work done on the box by the rope.

13. A spring is pulled with a force of **8.5N** acting at an angle of **17°** from the horizontal. Calculate the **horizontal component of force** acting on the spring.

14. A force of **15N** acts on a box as shown below.



Calculate or find:

a) **Horizontal** component of **force**.
b) **Vertical** component of **force**.

15. A new ship of mass **7.7×10^7kg** is guided out to sea by 2 tug boats.

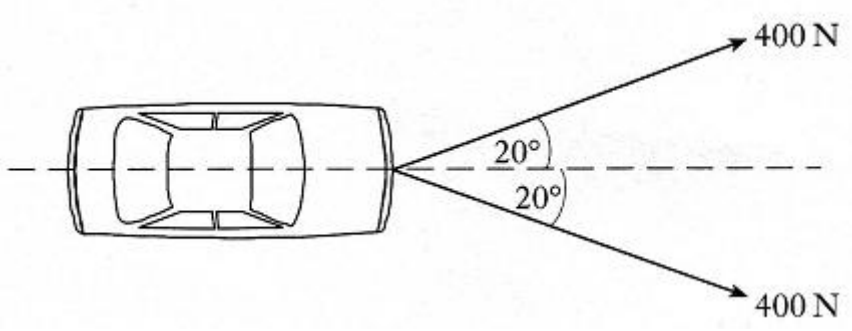
If each tug boat pulls the ship with a force of **2.5×10^6N** at an angle of **36°** on either side

of the horizontal then, **calculate or find**:

a) **Total horizontal force** exerted on the ship.
b) **Initial acceleration** of the ship.
c) **The total force of friction** acting on the ship if it then moves with a constant velocity. **(M+D's !!!!)**

16. Two boys are pulling a car of mass **800kg** along a level road surface with a pair of tow ropes,

which are attached horizontally as shown below.

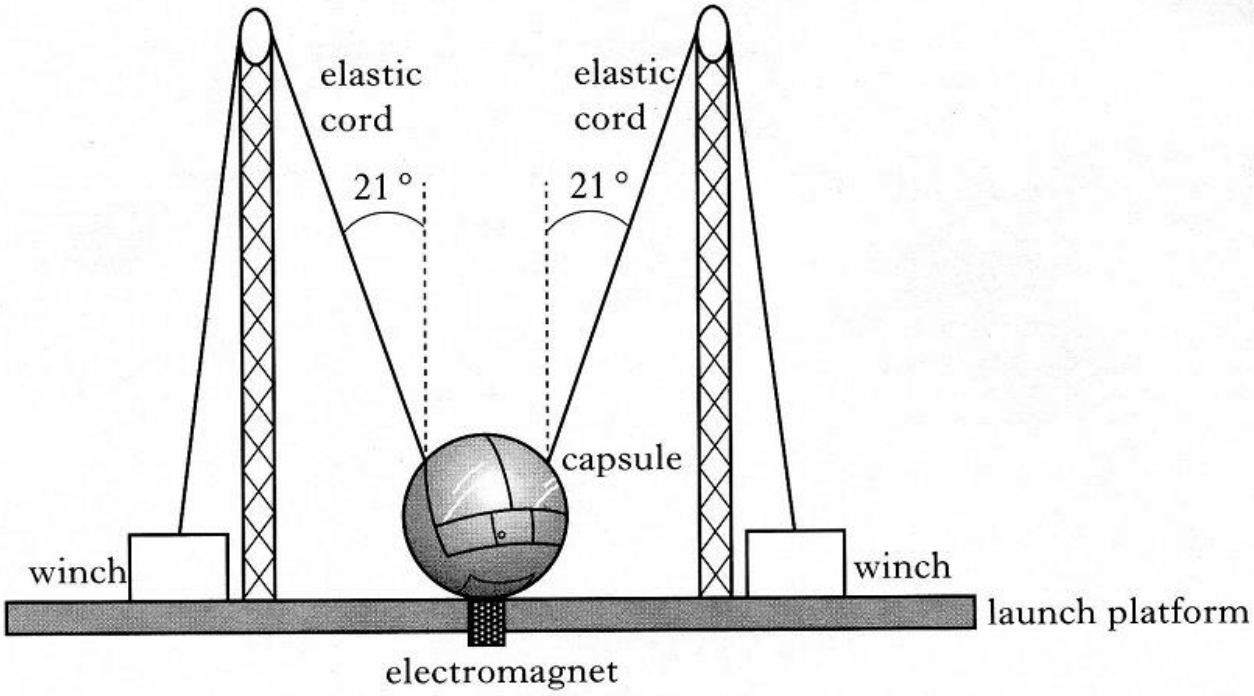


When the pull on each rope is **400N** as indicated above, the acceleration of the car is **0.1ms^{-2}**.

Calculate the **magnitude and direction of the frictional force**.

17.

A "giant catapult" is part of a fairground ride.



Two people are strapped into a capsule. The capsule and the occupants have a combined mass of 236 kg.

The capsule is held stationary by an electromagnet while the tension in the elastic cords is increased using the winches.

The mass of the elastic cords and the effects of air resistance can be ignored.

(*a*) When the tension in each cord reaches $4{\cdot}5 \times 10^3$ N the electromagnet is switched off and the capsule and occupants are propelled vertically upwards.

(i) Calculate the vertical component of the force exerted by **each** cord just before the capsule is released.

(ii) Calculate the initial acceleration of the capsule.

(iii) Explain why the acceleration of the capsule decreases as it rises.

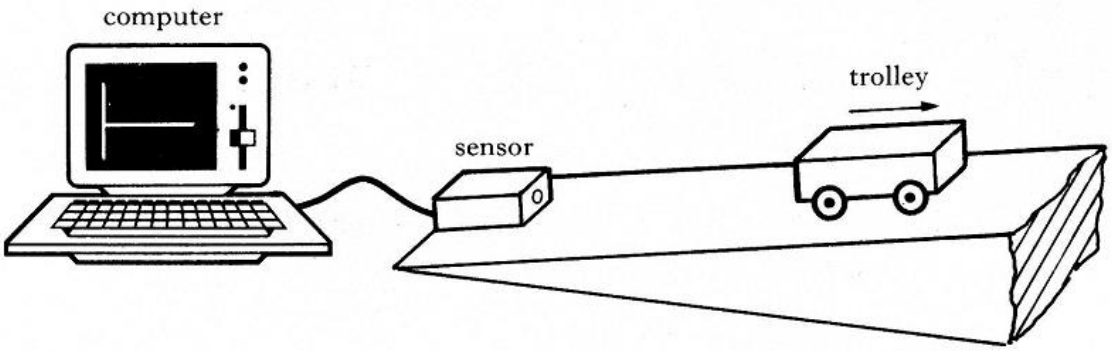
(*b*) Throughout the ride the occupants remain upright in the capsule.

A short time after release the occupants feel no force between themselves and the seats.

Explain why this happens.

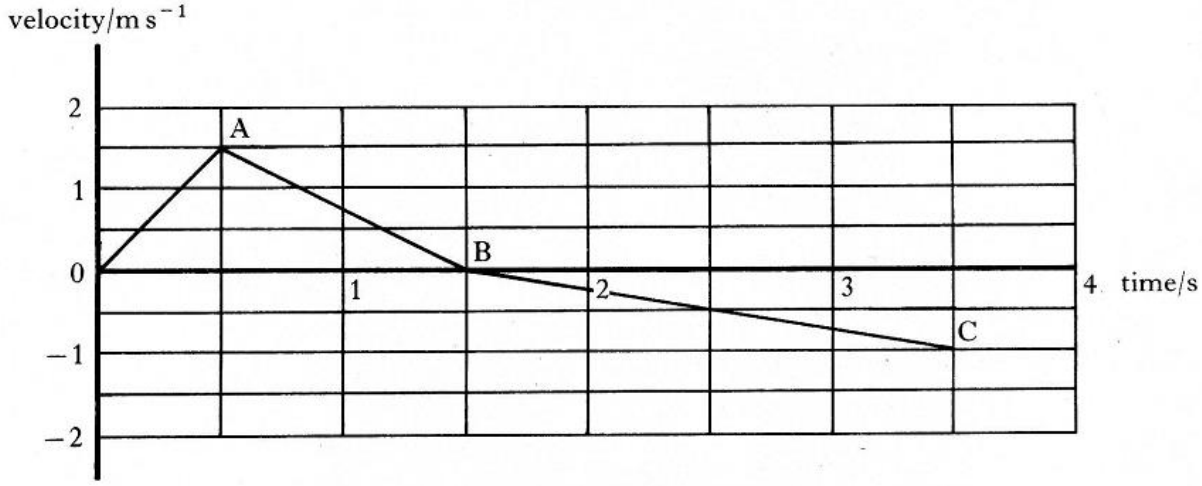
18.

The velocity of a trolley on a slope can be investigated using a computer and a sensor as shown below.



The sensor emits ultrasound pulses which are reflected from the trolley. The computer measures the time between emitted and reflected pulses and uses this information to calculate the velocity at regular times.

In an investigation, the trolley is given a sharp push **up** the slope and then released. The graph below shows the resulting velocity-time graph as displayed on the screen.



Point A on the graph corresponds to the instant at which the trolley is released.

(*a*) At what time is the trolley at its maximum displacement from the sensor? You must justify your answer.

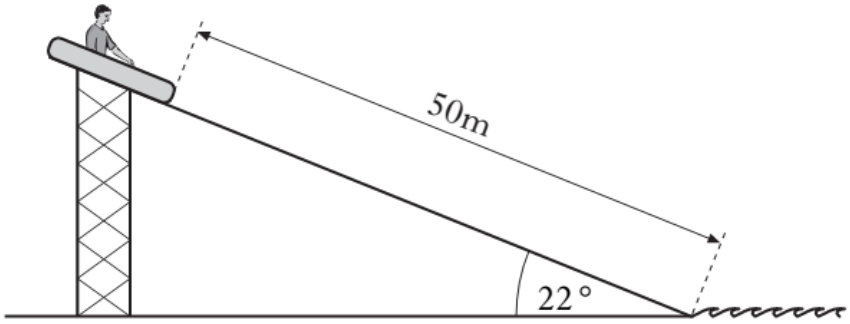
(*b*) On the square-ruled paper provided, draw the corresponding acceleration-time graph of the motion.

(*c*) Draw a diagram to show the forces acting on the trolley as it moves **up** the slope after the push is removed. Show only forces or components of forces acting parallel to the slope.

(*d*) Explain, in terms of the forces acting on the trolley, why the magnitude of the acceleration from A to B differs from the magnitude of the acceleration from B to C.

19.

A fairground ride consists of rafts which slide down a slope into water.



The slope is at an angle of 22 ° to the horizontal. Each raft has a mass of 8·0 kg. The length of the slope is 50 m.

A child of mass 52 kg sits in a raft at the top of the slope. The raft is released from rest. The child and raft slide together down the slope into the water. The force of friction between the raft and slope remains constant at 180 N.

(*a*) Calculate the component of weight, in newtons, of the child and raft down the slope.

(*b*) Show by calculation that the acceleration of the child and raft down the slope is 0·67 m s^{-2}.

(*c*) Calculate the speed of the child and raft at the bottom of the slope.

(*d*) A second child of smaller mass is released from rest in an identical raft at the same starting point. The force of friction is the same as before.

How does the speed of this child and raft at the bottom of the slope compare with the answer to part (*c*)?

Justify your answer.

20. A **canal boat** is **pulled** by **two horses** on either side of a canal bank.

Each horse is pulling the canal boat **Due South** with a force of **530N** and at an angle of **34° to the vertical**.

The **horse** on the **West Bank** continues to pull the boat **as before**, but the horse on the **East Bank** then pulls with the **same force** but at an angle of **30°**.

Calculate the new resultant force acting on the canal boat.