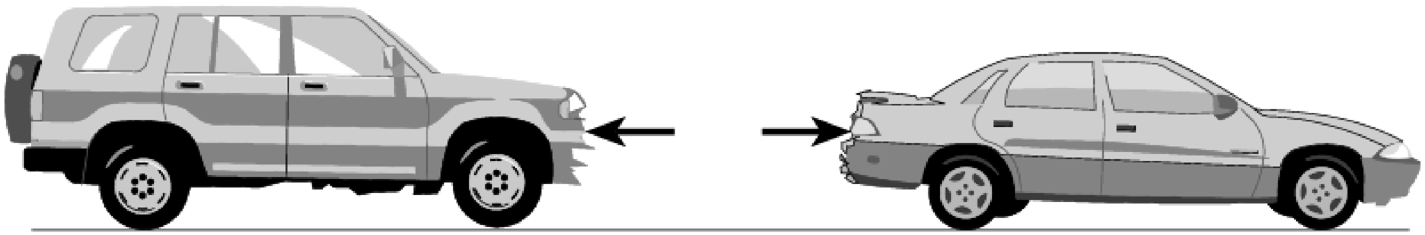
Homework assignments

Self study	**Homework (to be handed in)**
Read: pp. 94-111 Work through all the examples.	Exercise 7A: 1 Exercise 7B: 1 (b), (c), 3

7. Newton's third law

- Understand that forces occur in equal and opposite pairs, and be able to identify the objects on which each of the pair of forces act
- Be able to apply Newton's third law in situations involving two interacting objects
- Understand what is meant by tension in a string
- Be able to solve problems on pairs of objects connected by a string, which may pass over a smooth peg or a light pulley

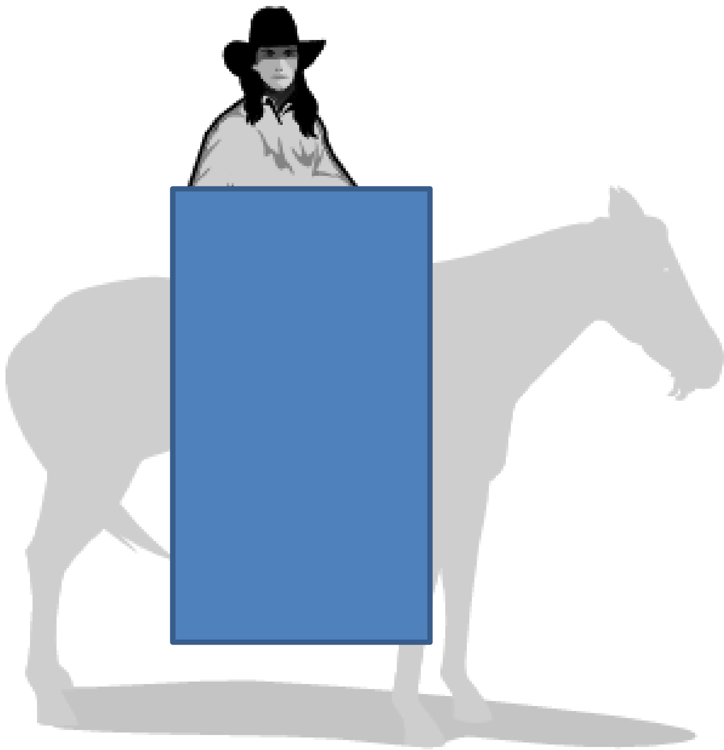
7.1 Forces in pairs



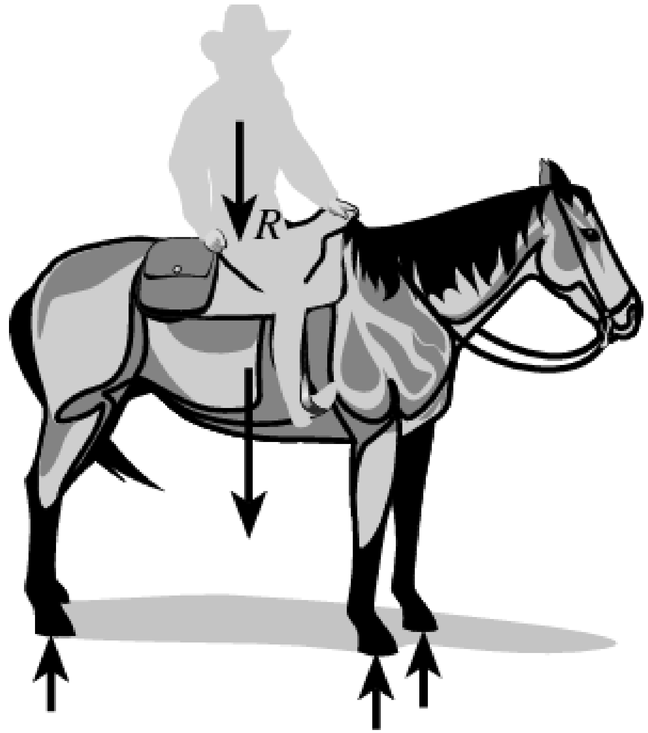
Newton's third law If an object A exerts a force on an object B, then B exerts a force on A of the same magnitude in the opposite direction.

Normal contact forces

Forces on the rider

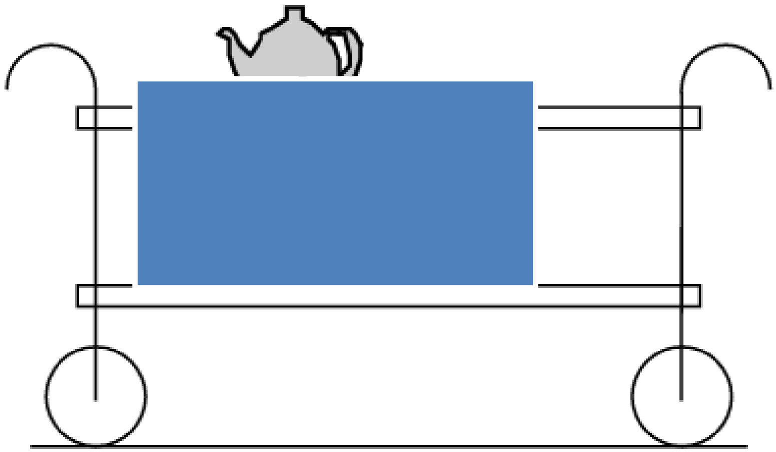


Forces on the horse

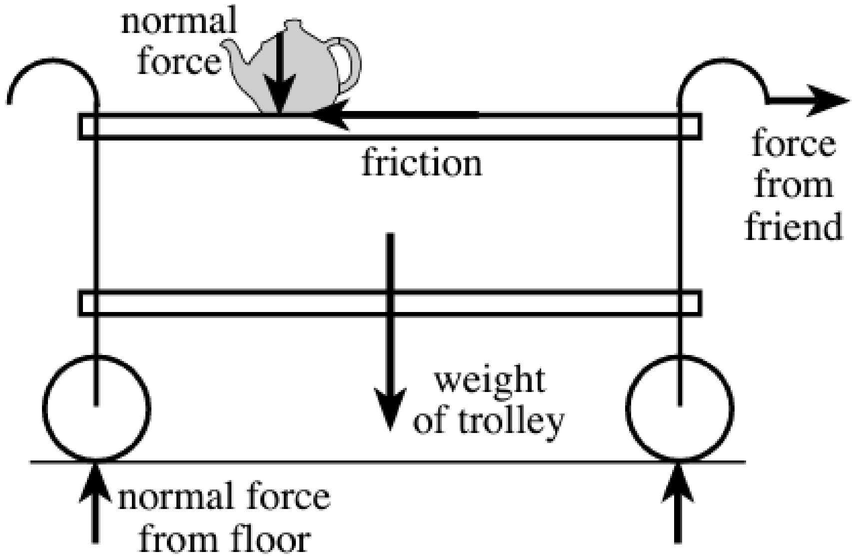


Frictional forces

Forces on the teapot



Forces on trolley



One person is holding the trolley and someone pushes the teapot to the left

Gravity

Moon going round the earth due to earth's gravity

Effect of gravitational force of the moon on the earth?

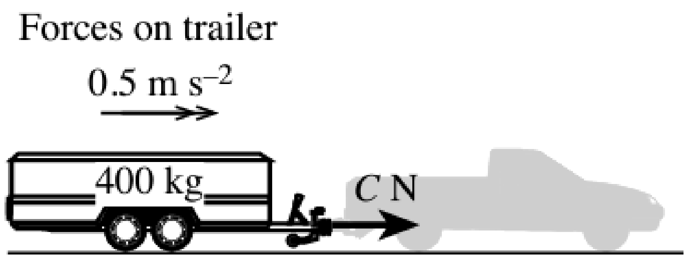
What about any other object?

7.2 Calculations using Newton's third law

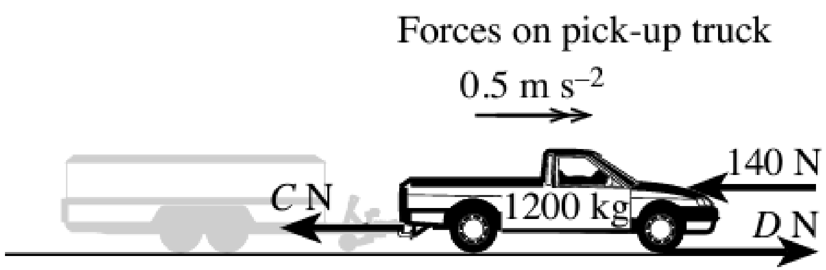
Example 7.2.1

A pick-up truck of mass 1200 kg tows a trailer of mass 400 kg. There is air resistance of 140 N on the truck, but the resistance to the motion of the trailer is negligible. A coupling connects the trailer to the truck. Find the force from the coupling, and the driving force on the truck, when the truck and trailer accelerate at 0.5 m s^{-2}.

Give the forces on the trailer



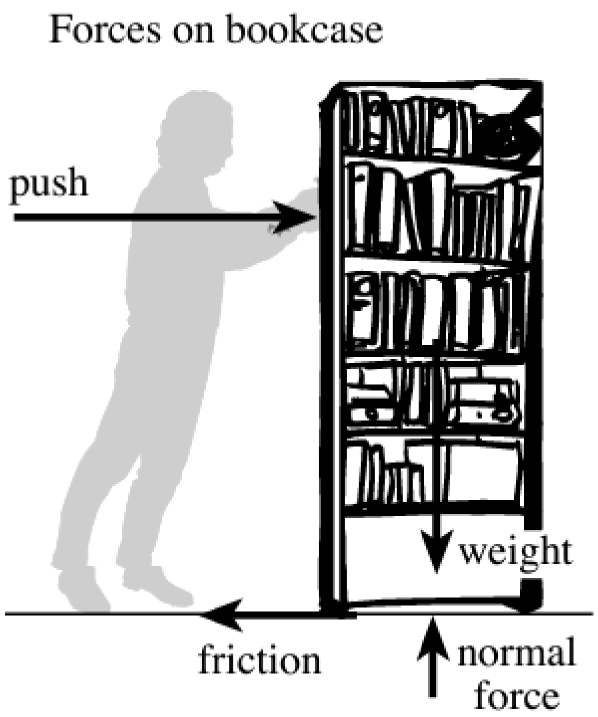
Give the forces on the truck



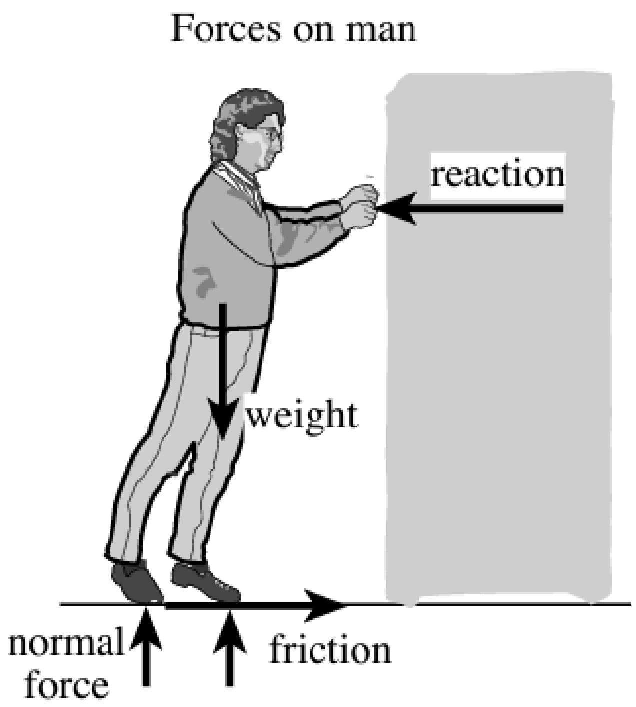
Example 7.2.2

A man of weight 750 N tries to push a bookcase of weight 1200 N across the floor. The coefficient of friction between the bookcase and the floor is 0.4. How rough must the contact between his shoes and the floor be for this to be possible?

Give the forces on the bookcase



Give the forces on the man



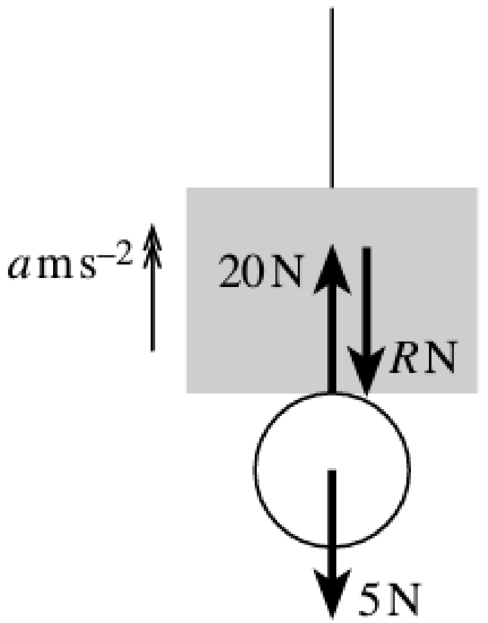
Example 7.2.3

A bar magnet of mass 0.2 kg hangs from a string. A metal sphere, of mass 0.5 kg, is held underneath the magnet by a magnetic force of 20 N. The string is then pulled upwards with a force of T N. Find the largest possible value of T if the sphere is not to separate from the magnet.

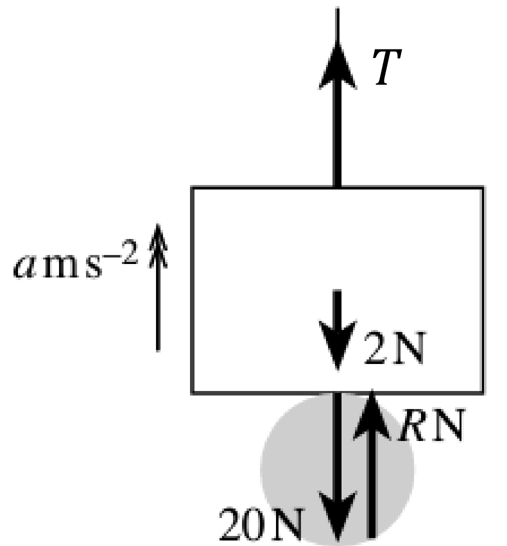
Give the forces on the sphere

Give the forces on the magnet

Forces on sphere



Forces on magnet



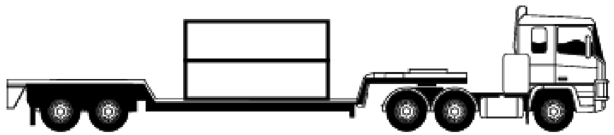
Example 7.2.4

A student has two books lying flat on the table, one on top of the other. She wants to consult the lower book. To extract it, she pushes it to the left with a force of Q N. To prevent the upper book moving as well, she exerts a force of P N on the upper book to the right. The lower book then slides out, and the upper book remains stationary. The weights of the upper and the lower books are 8 N and 7 N respectively. Between the two books the coefficient of friction is 0.25, and between the lower book and the table it is 0.4. Calculate P and Q.

Self study

Class exercises
Exercise 7A

5 A reckless truck-driver loads two identical untethered crates stacked one upon the other as shown in the diagram. No sliding takes place. Make separate sketches to show the forces acting on each crate when the truck travels on a horizontal straight road



(a) with constant speed, (b) while accelerating, (c) while decelerating.

Each crate has mass 250 kg. Calculate the magnitude of the frictional force exerted on

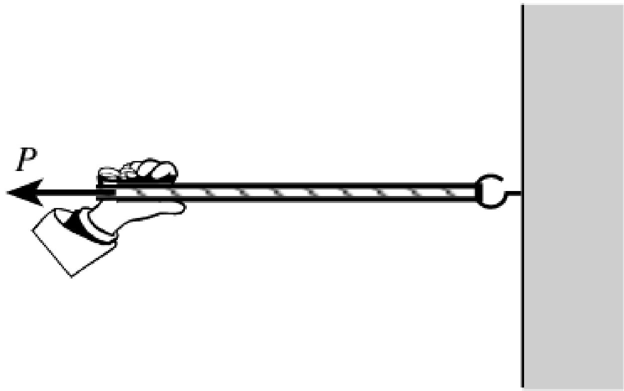
(i) the upper crate by the lower, (ii) the lower crate by the deck of the truck,

when the acceleration of the truck is 1.5 m s^{-2}.

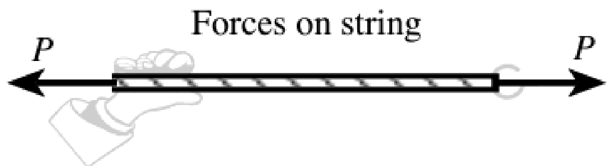
7.3 Strings, ropes, chains and cables

Consider a string pulled with force *P*

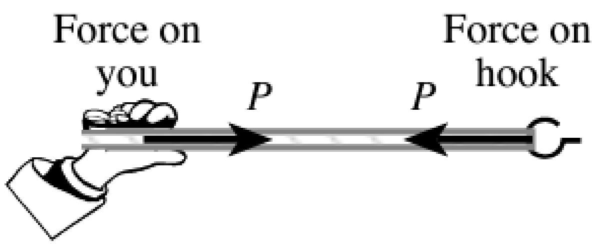
Ignore mass of string ('light')



If in equilibrium, draw the forces on the string



Draw the force the string exerts in the objects attached to its ends



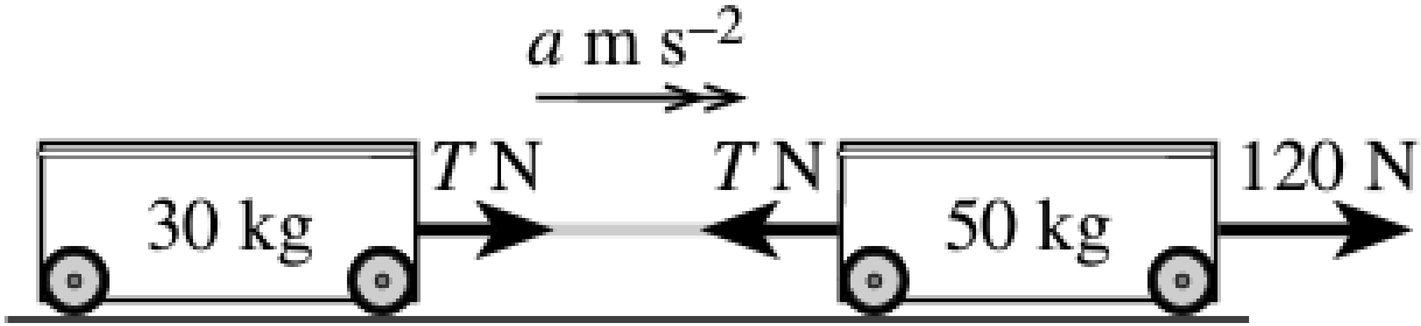
7.3 Strings, ropes, chains and cables

A light string exerts forces of equal magnitude on the objects attached to its two ends. These forces act along the line of the string, and are directed inwards at each end. The magnitude of the force at either end is called the **tension** in the string.

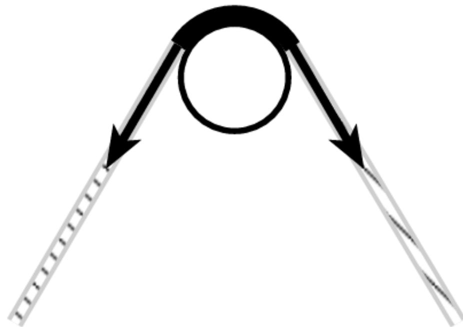
The difference between a rod and a string, rope or cable is that it can also exert forces which are directed outwards at each end. The magnitude of such a force is called the **thrust** in the rod.

Example 7.3.1

Suppose that in Fig. 7.13 the truck on the left has mass 30 kg, and the truck on the right has mass 50 kg. The truck on the right is pulled along with a force of 120 N. Calculate the tension in the cable.



7.4 Pegs and pulleys



Assume string cannot stretch

Assume surface is smooth

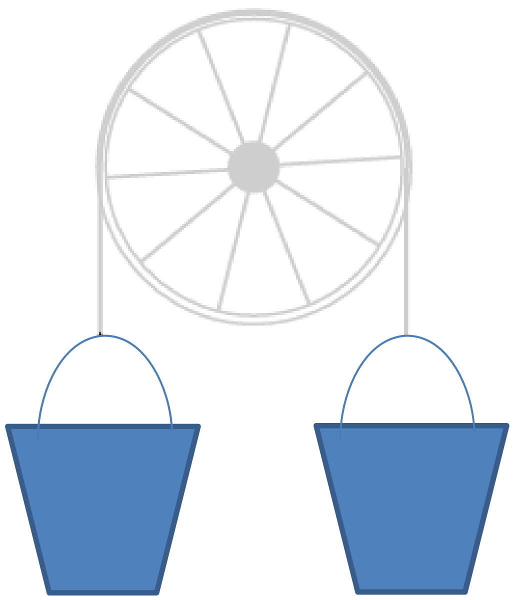
For a wheel or pulley assume no friction

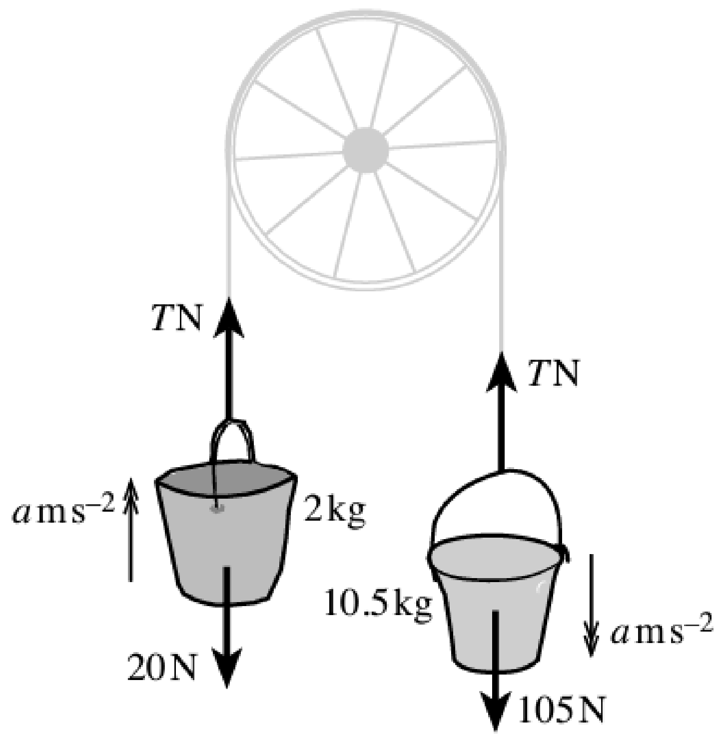
For a wheel or pulley is 'light' (or size can be ignored)

When a string passes round a smooth peg, or a light pulley with smooth bearings, the tension in the string is the same on either side.

Example 7.4.1

Repairs are being carried out in a tall building. A wheel is attached at the top of the scaffolding with its axis horizontal. A rope runs over the rim of the wheel and has buckets of mass 2 kg tied to it at both ends. One bucket is filled with 8.5 kg of rubble and then released, so that it descends to ground level. With what acceleration does it move?

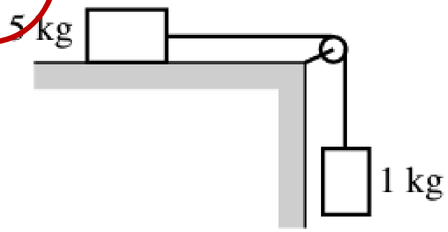




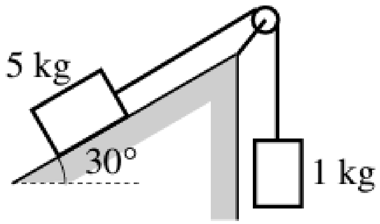
Class exercises
Exercise 7B

1 In the cases illustrated in the following diagrams the strings pass over small light pulleys. The contacts between the blocks and the surfaces are rough, except where they are indicated as smooth in parts (d), (e) and (f). The blocks are at rest and the strings taut. In each case find the tension in the string and the frictional force exerted by each surface on the block with which it is in contact.

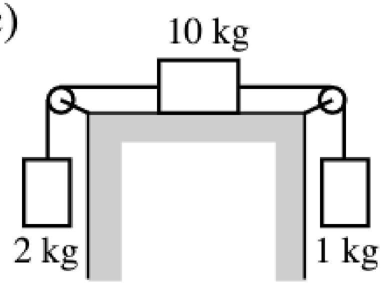
(a)



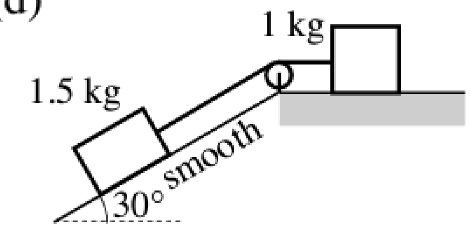
(b)



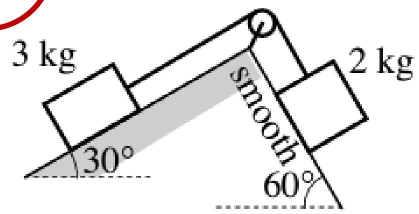
(c)



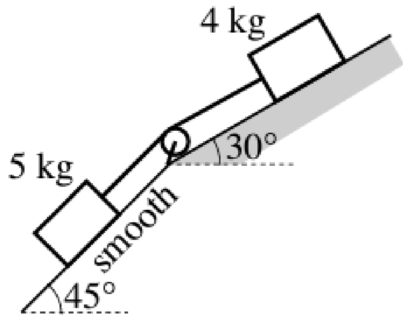
(d)



(e)

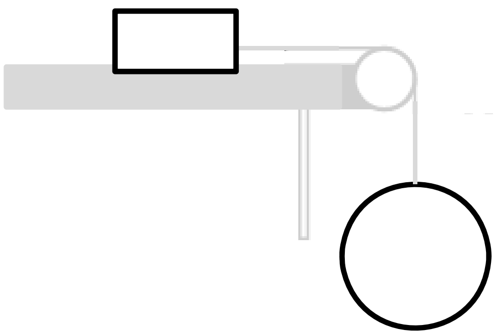


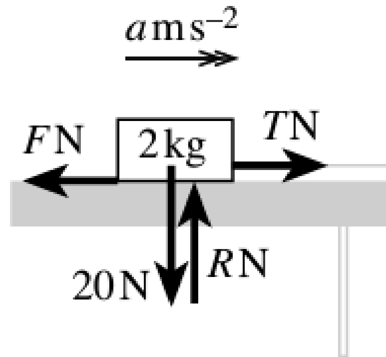
(f)



Example 7.4.2

A box of mass $2\ \text{kg}$ is placed on a table. A string attached to the box passes over a smooth peg at the edge of the table, and a ball of mass $1\ \text{kg}$ is tied to the other end. The two straight sections of the string are horizontal and vertical. If the coefficient of friction between the box and the table is 0.2, find the acceleration of the box and the ball.





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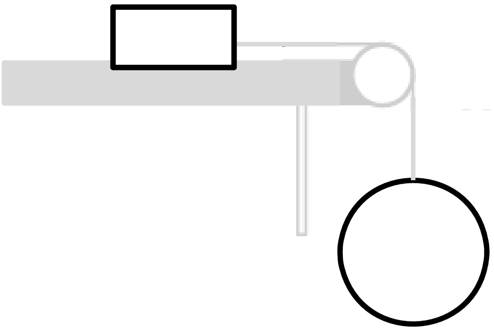
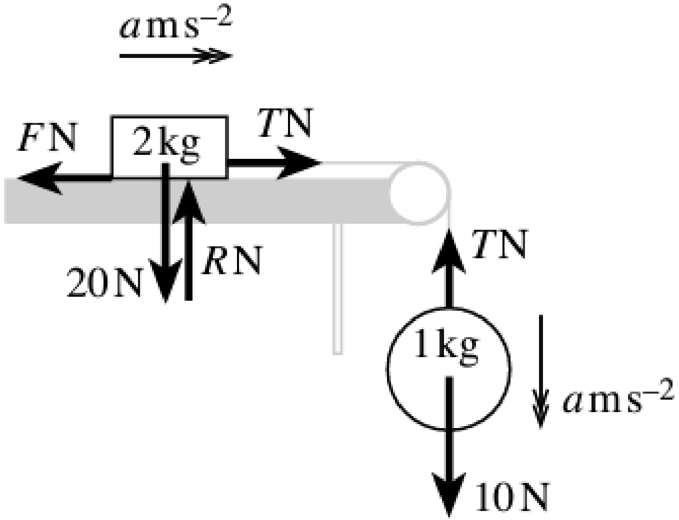
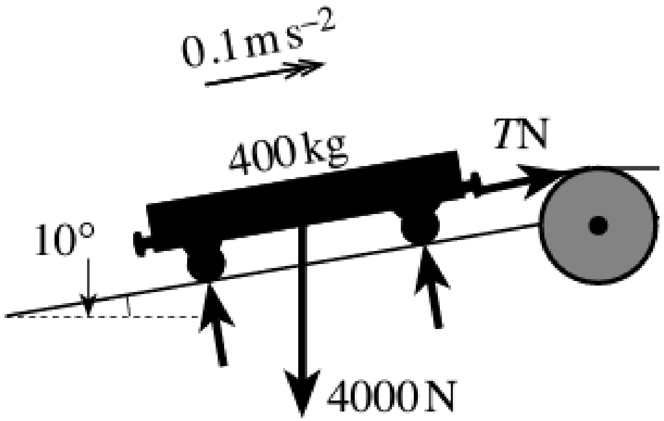




Example 7.4.4

On a construction site a truck of mass 400 kg is pulled up a 10° slope by a chain. The chain runs parallel to the slope up to the top, where it passes over a cog wheel of negligible mass. It then runs horizontally and is attached to the rear of a locomotive of mass 2000 kg. Neglecting any resistances, calculate the driving force needed to accelerate the truck up the slope at $0.1\ \text{m s}^{-2}$.



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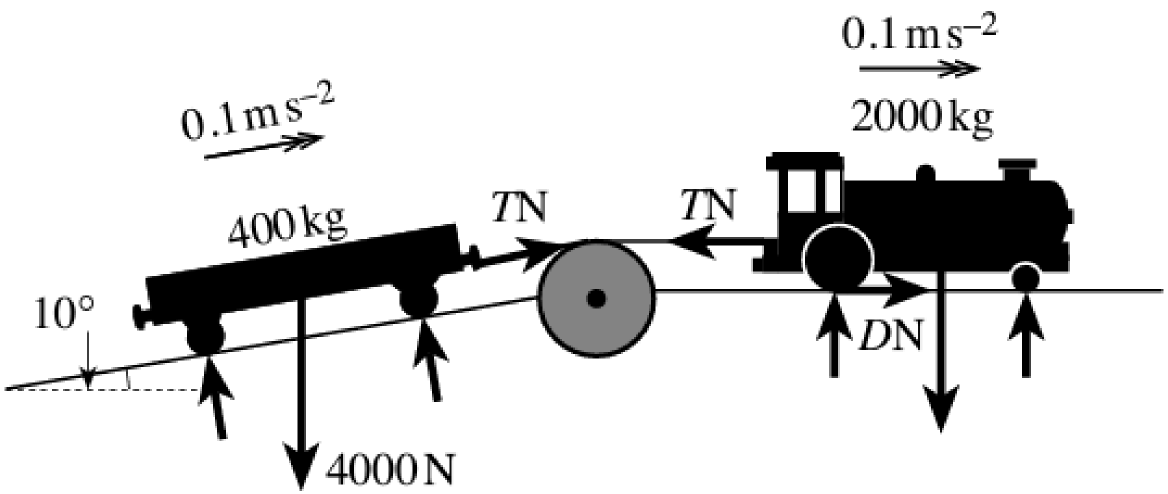
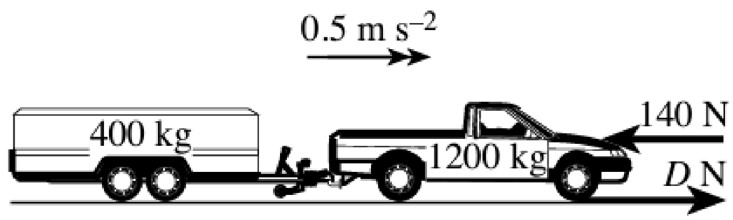


7.5 Internal and external forces

Suppose that a vehicle of mass 1600 kg accelerates at 0.5 m s^{-2}, and that the motion is opposed by a resistance of 140 newtons. What is the driving force, D newtons?



When an object is made up of two parts, each of which has the same velocity and acceleration, you can apply Newton's second law either to the object as a whole or to the parts separately.

For the object as a whole, forces of interaction between the two parts are **internal forces**, and are not included in the equation.

For the separate parts, the forces of interaction of each on the other are **external forces**, and are included in the equations.