Lesson Two — Forces

Aims

The aims of this lesson are to enable you to

- define a force
- give examples of forces
- draw diagrams involving forces
- tackle problems involving forces

Context

Now that you have an overview of the subject as a whole, it is time to tackle a topic which will be of significance throughout your study - forces. You will also enhance your skills in constructing diagrams.

Bostock and Chandler, pp. 8–11.

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Forces

If an object which was initially at rest starts to move something must have caused this motion. This 'something' is called a FORCE. In practice there are many different types of force, but we can often consider them basically as either a push or a pull. Besides causing motion, there are also forces which prevent motion, or impede it; particular examples of these are friction and resistance.

Newtonian Mechanics

The type of Mechanics we are studying in this course is often known as **Newtonian Mechanics**, after Isaac Newton who discovered many of the laws we shall be investigating. Probably his most famous discovery was that of gravity. Newton considered what caused an apple to fall from a tree. Since the apple, which was originally at rest, starts to move when it falls a force must have caused this. This force is known as the gravitational force, or weight. The weight force acts on all objects but is found to vary slightly for a given object at different places on the earth's surface.

Mass and Weight

This difference in weight is apparent if a spring balance is used to weigh an object. If, however, a lever balance, with two scale pans is used, the object would weigh the same wherever it was on the earth. This apparent contradiction is because the spring balance measures directly the pull of the gravitational force, whereas the lever balance compares the pull of gravity on the object with that on a set of standard weights, so although the actual amount of matter in an object - its mass - does not change no matter where it is on the earth's surface, its weight may vary slightly, from place to place.

Study the sections of the text on force, weight, mass and diagrams, together with the worked examples.

Note the various names used for the different forces, and the letters which are commonly used in diagrams to denote them. It makes the solving of problems in later work very much simpler if, for instance, a tension force is denoted by T, rather than X. The general convention in Mechanics is to use capital letters to denote forces, such as F, R, T, W.

Normal Contact Forces

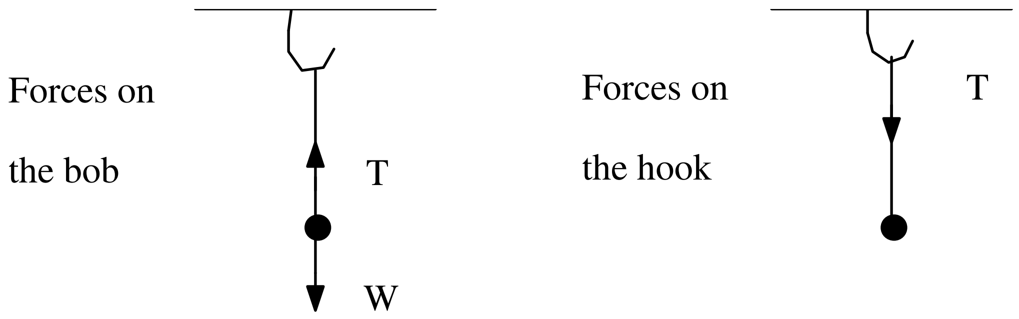
The reaction force, R, which always occurs when two bodies are in contact, acts at right angles to the surface of contact, and so is often called a *normal* contact force. In particular for an object standing on level ground, the reaction will be vertically upwards, and for an object leaning against an upright wall, the reaction will be horizontal. For two curved surfaces in contact, the reaction will be at right angles to the common tangent at the point of contact. So, with two circles, it will be a radius to each.

In the last two worked examples note how F_1, F_2 and R_1, R_2 are used to denote two different frictional forces and reactions. Another way to distinguish different forces of the same type would be to call the ends of the ladder, for example, A and B, and then the forces at A could be F_A and R_A, and those at B would be F_B and R_B. The reason for distinguishing between the forces is that the actual values of these forces would not necessarily be equal.

Pairs of Forces

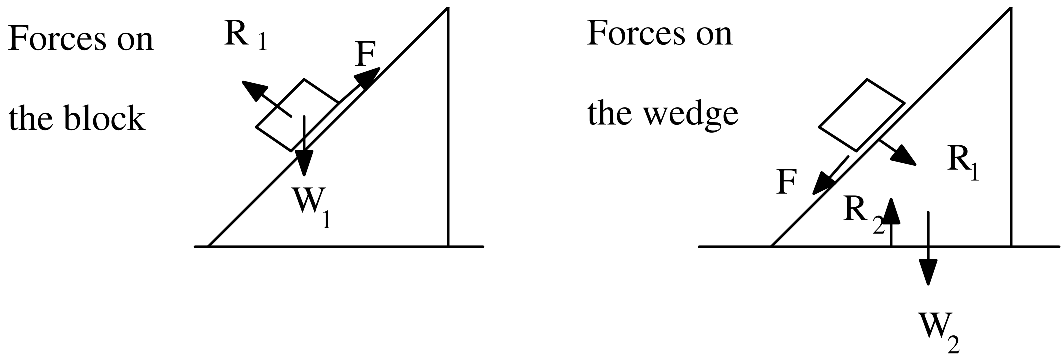
It is important to realise that, in general, forces occur in pairs. So, for example, if a block is resting on a horizontal surface, there is a contact force from the surface onto the block supporting it, and, equally, there will be a contact force from the block onto the surface which will be equal in magnitude, but opposite in direction to that from the surface onto the block. You experience this when you hold a heavy object in your hand. The force you feel is the contact force from the object. It is not the weight force of the object, since a weight force can only act on that particular object, although, if you and your hand are still, it will be of equal magnitude to the weight of the object.

Another example of a pair of forces is tension in a string. If a heavy bob is suspended from a hook by a light string, there will be a tension upwards in the string on the bob keeping it from falling, balancing out the weight force. Equally, there will be a tension in the string on the hook, pulling downwards.



Assuming the string is light, so that its weight can be ignored, these two tensions will be equal in magnitude. This opposing tension can be felt if you try swinging the bob around on the end of the string. You will feel quite a large force pulling on your hand.

A further situation in which we see pairs of forces in operation is when there is friction between two objects which are both free to move. If we consider a rough block sliding down the rough inclined surface of a wedge, which rests on a smooth table, we can draw diagrams of the forces acting on the block and on the wedge.



Since the block is trying to slide down the wedge, F will act upwards on it, and there will then be an equal and opposite force F acting downwards along the slope of the wedge.

Sometimes when there are situations like this with more than one object free to move, it is not always easy to decide which way friction will act. In later work we shall see that it does not matter which way we decide to label F, since, if we have chosen the wrong direction, when we calculate the value of F, it will turn out to be negative.

These equal and opposite forces are sometimes relevant to the problem, but at other times they can be ignored. For instance, when an object rests on a horizontal surface, we are not usually concerned with the forces on this surface, only those on the object.

When considering the forces acting on objects, care must be taken not to introduce forces which do not exist! For example, if a ball is thrown into the air, initially there will be a force which starts its motion, but once the ball has left the thrower's hand, the only force acting on it (apart from any air resistance) will be its weight. There will be no imaginary force pushing it along!

The weight of an object is caused by the force of attraction between it and the earth. An object falls towards the earth with an acceleration due to gravity; this is 9.8 m/s^2.

Drawing Diagrams

When tackling Mechanics problems, one of the first things to do is to draw a diagram of the situation, showing all relevant information on it, in particular all the forces which relate to the problem. Diagrams should be neat and clearly labelled but not be over complicated, and so cause confusion. Never try to put so much information on the diagram that it is impossible to decide what is relevant and what is not!

Now work through Exercise 1b. Diagrams for the questions in this exercise are provided over the page but do not look at these until you have tried to draw and label them yourself.

Diagrams for Questions in Exercise 1b

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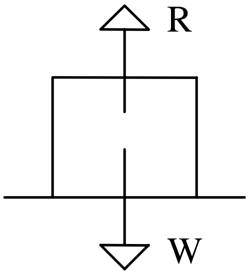

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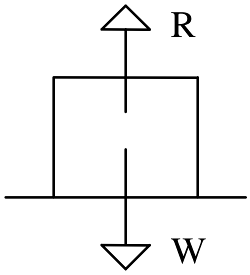

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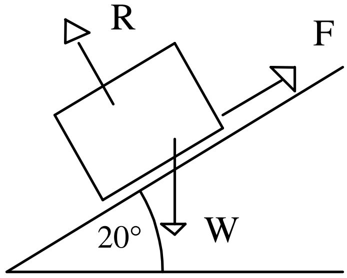

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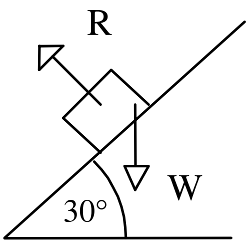

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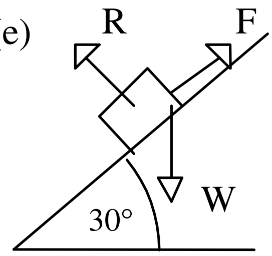

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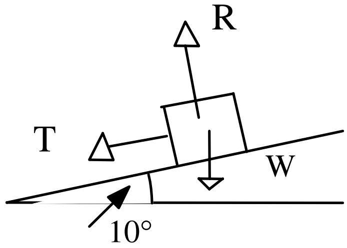

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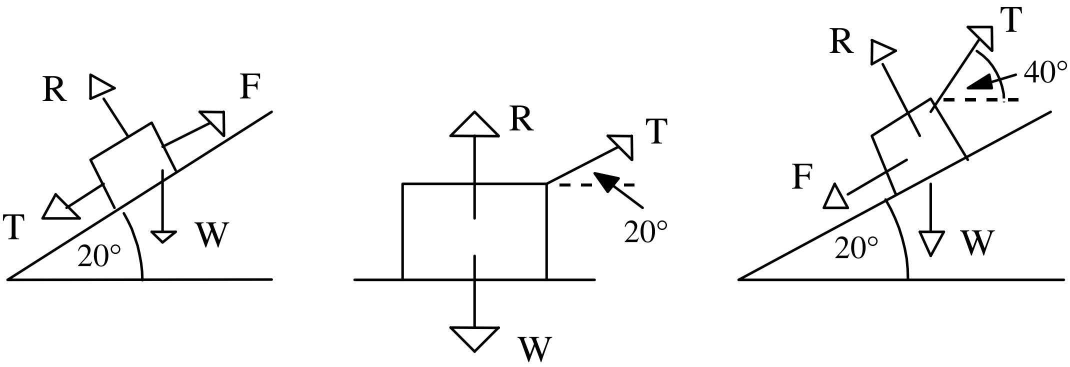

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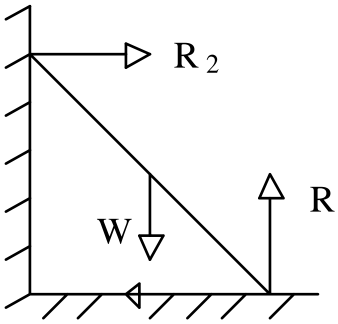
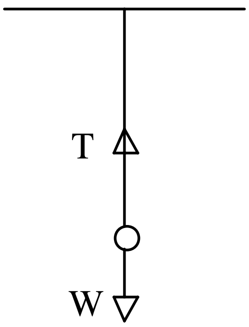


3. (a)



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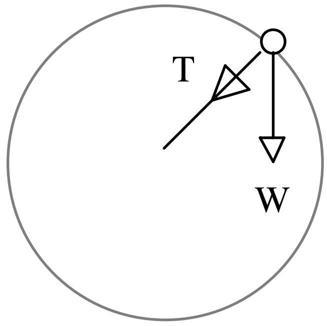

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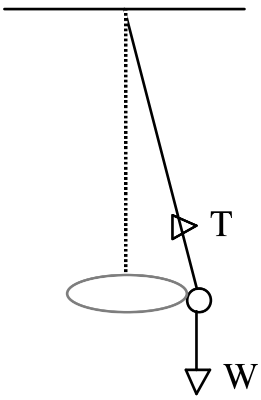

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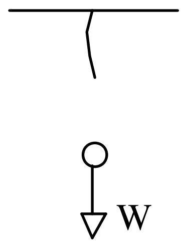

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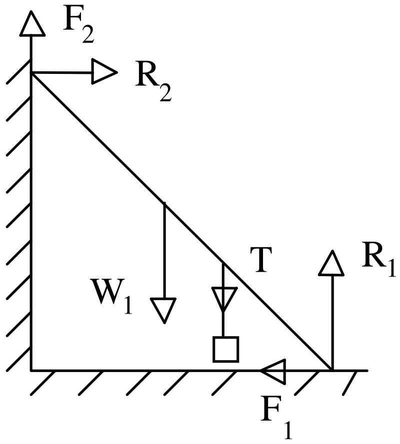
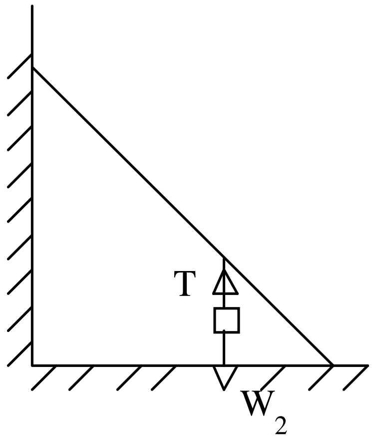
5. (a)



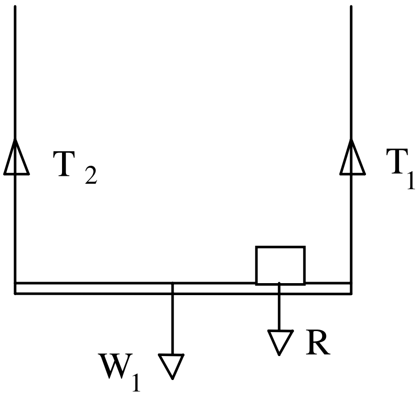
Forces on ladder

(b)



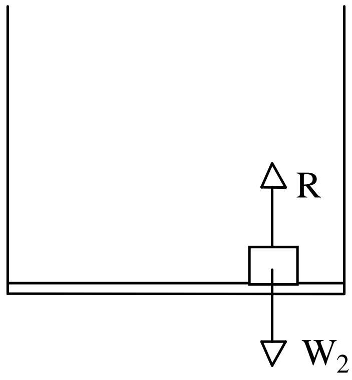
Forces on block

6. (a)



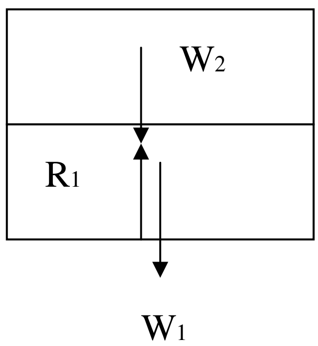
Forces on plank

(b)



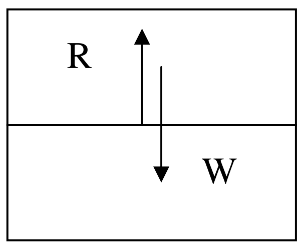
Forces on block

7. (a)



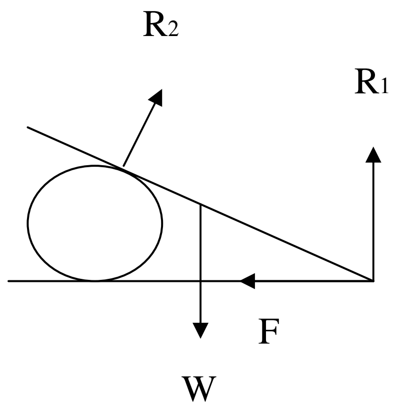
Forces on bottom brick

(b)



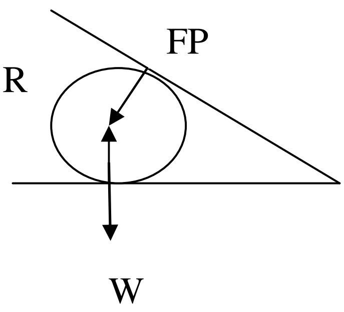
Forces on top brick

8. (a)



Forces acting on plank

(b)



Forces acting on cylinder