Mastering Physics

MODULE 2

NSW

Dynamics

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Contents

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Words to Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Put to use in a particular situation.

assess Make a judgement about the value of something.

calculate Find a numerical answer.

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Estimate, measure or note how things are similar or different.

construct Represent or develop in graphical form.

contrast Show how things are different or opposite.

create Originate or bring into existence.

deduce Reach a conclusion from given information.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Talk or write about a topic, taking into account different issues or ideas.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Make something clear or easy to understand.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

hypothesise Suggest an explanation for a group of facts or phenomena.

identify Recognise and name.

interpret Draw meaning from.

investigate Plan, inquire into and draw conclusions about.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers.

measure Find a value for a quantity.

outline Give a brief account or summary.

plan Use strategies to develop a series of steps or processes.

predict Give an expected result.

propose Put forward a plan or suggestion for consideration or action.

recall Present remembered ideas, facts or experiences.

relate Tell or report about happenings, events or circumstances.

represent Use words, images or symbols to convey meaning.

select Choose in preference to another or others.

sequence Arrange in order.

show Give the steps in a calculation or derivation.

sketch Make a quick, rough drawing of something.

solve Work out the answer to a problem.

state Give a specific name, value or other brief answer.

suggest Put forward an idea for consideration.

summarise Give a brief statement of the main points.

synthesise Combine various elements to make a whole.

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Forces

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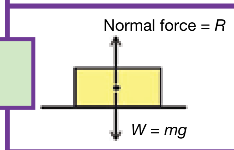
2.1 Forces, Equilibrium and Newton's First Law

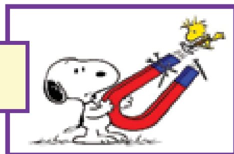
Using Newton's laws of motion, describe static and dynamic interactions between two or more objects and the changes that result from a contact force – a force mediated by fields.

Types of forces

Contact forces

Force	Example	Description
Applied forces		Hitting a ball, punching a bag, kicking a ball, pushing a swing, opening a door, cutting bread, hammering a nail.
Frictional forces		Between tyres and the road, slowing you down on a slide, makes hands warm when you rub them together.
Normal forces		Upward force of floor on you as you stand, of chair on you as you sit, on book resting on table, also called reaction forces.
Drag forces		Air resistance, slowing swimmers down, why objects fall slower through oil than through water, why there is terminal velocity.
Tension forces		Bending a ruler, stretching a rubber band, pulling a bridge cable tight, twisting a bar, forces in ropes, cables, strings and wires.
Spring forces		In springs that are compressed or stretched, act in opposite direction to the applied forces, compression or tension forces.

Forces acting at a distance

Force	Example	Description
Magnetic forces		Magnetic field surrounds magnets and electric currents, put magnetic forces on charges. Like magnetic poles repel, unlike poles attract.
Electrical forces		Electric fields surround charges and apply forces to other charges. Like charges repel, unlike charges attract.
Gravitational forces		Force of attraction between all masses in the Universe. Gives masses weight and often called weight force.

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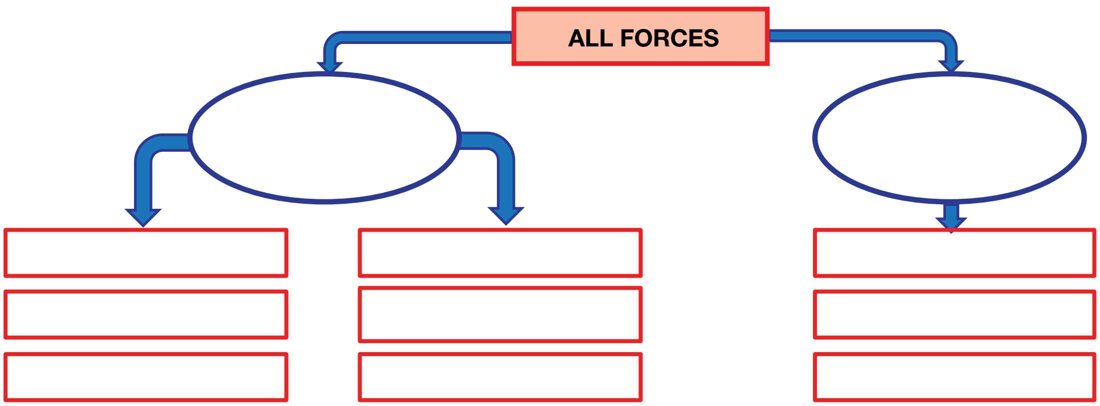
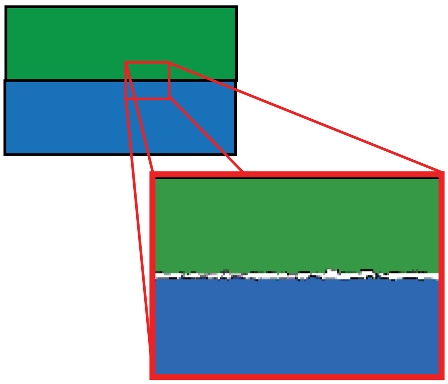
Sample Questions

1. Complete the diagram.



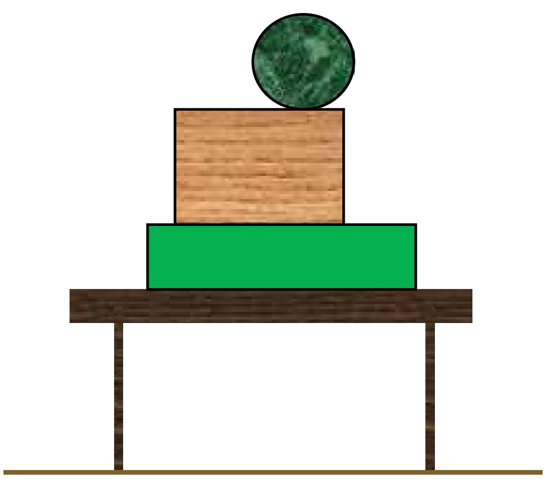
2. Explain, in terms of forces, what the diagram on the right is showing.



3. The diagram below shows three objects on top of each other on a table.

(a) On a copy of this diagram label four gravitational forces and four normal forces.

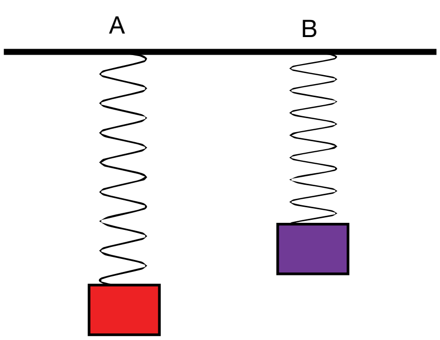
(b) Label each force.



4. The diagram shows the two different masses hanging on the same spring.

(a) Suggest a reason the spring is extended more in A than in B.

(b) Which spring will have the greater tension set up within it? Justify your answer.



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Equilibrium and Newton's first law

- A body is said to be in **equilibrium** if it is at **rest** or if it is **moving with uniform velocity**.
- Note that being in equilibrium does not mean that no forces act.
- When two or more forces act on a body which is in equilibrium, the net force must be zero.
- There will be no acceleration, but the body may still move with constant velocity.

The concept of equilibrium is the focus of **Newton's first law of motion**.

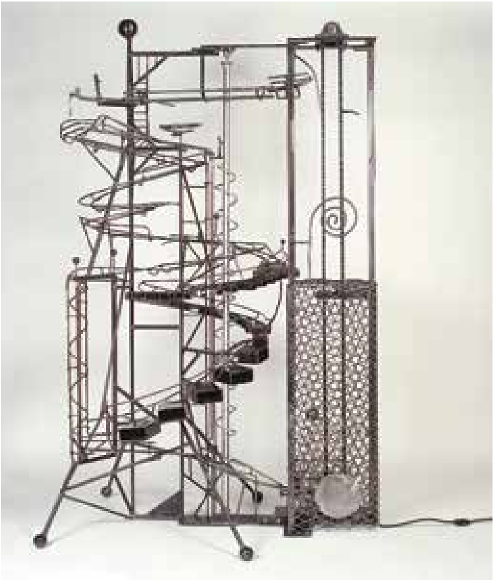
A body at rest, or moving with constant velocity, will remain at rest or moving with constant velocity unless an unbalanced force acts on it.

Types of equilibrium

- **Static equilibrium** exists if all the forces acting on a body add to zero, and the body is at rest.
  - A folder resting on your desk.
  - Your car parked in the school car park.
  - A can of drink sitting on a shelf in the fridge are all in static equilibrium.
- **Dynamic equilibrium** exists if all the forces acting on a body add to zero, and the body is moving at constant velocity.
  - A car moving at constant speed.
  - A parachute jumper falling towards the ground at constant (terminal) velocity.
  - A comet moving through space at constant velocity are all in dynamic equilibrium.

Sample *Questions*

1. State the conditions needed for translational equilibrium.
2. Explain the idea of static equilibrium.
3. Explain the idea of dynamic equilibrium.
4. Identify these as being in static or dynamic equilibrium or as not being in equilibrium.
   (a) Light fitting hanging from the ceiling.
   (b) Ski jumper moving down the slope towards the jumping ramp.
   (c) Plane taking off.
   (d) A computer on your desk.
   (e) Tree branches swaying in the wind.
   (f) Mudslide down the side of a hill.
   (g) Apollo 11 coasting between the Earth and the Moon.
   (h) Arrow poised in bow ready to fire.
   (i) Car travelling at constant speed up hill.
   (j) Car travelling at constant speed on flat road.
   (k) Car travelling at constant speed down hill.



At the moment the ball at the top of this mechanical maze is in static equilibrium – but … touch it and the equilibrium might be lost.

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2.2/3 Forces In One and Two Dimensions

Explore the concept of net force and equilibrium in one-dimensional and two-dimensional contexts using algebraic addition, vector addition and vector addition by resolution into components. Apply the following relationships, solve problems or make quantitative predictions about resultant and component forces using $F_x = F\cos\theta$ and $F_y = F\sin\theta$.

Forces in one and two dimensions – vector revision

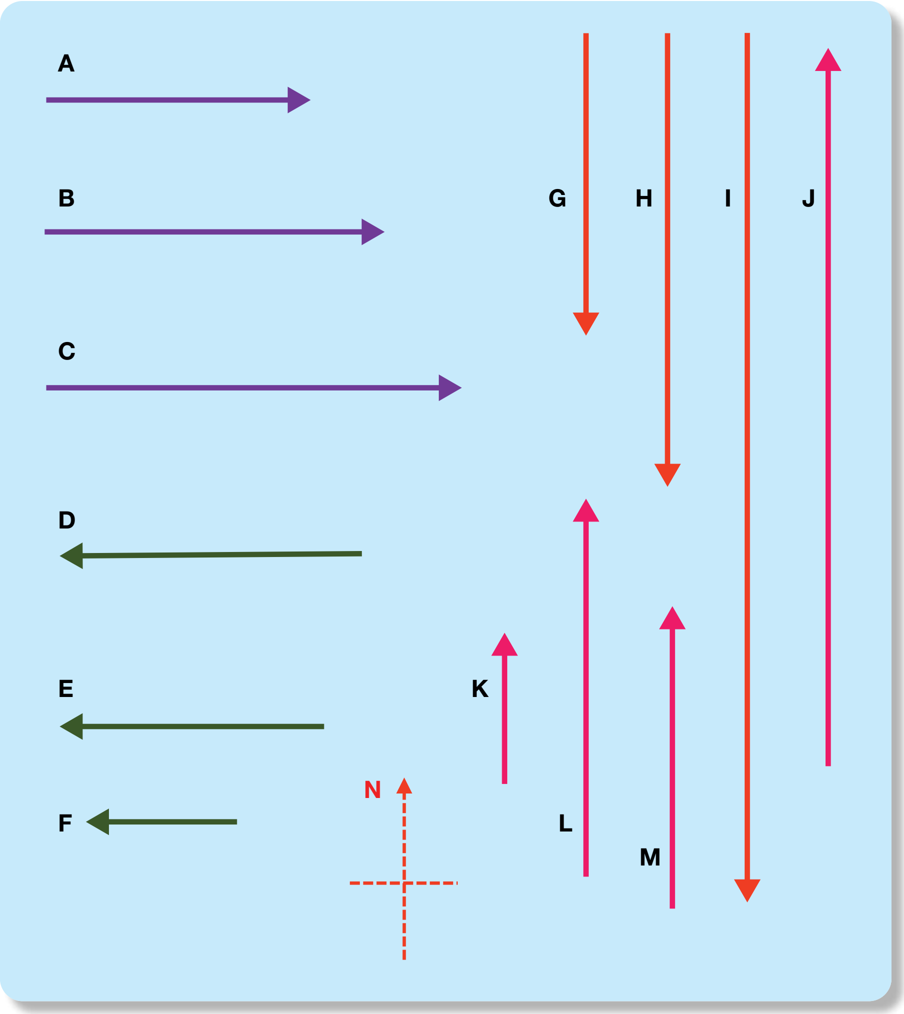
- **Forces are vector quantities** and can therefore be represented by scale diagrams.
- Force is measured in **newtons**, symbol **N**.

Sample Questions

Refresh your skills by doing the questions below which refer to the force vectors in the diagram.

The vectors have been drawn using a scale where 1 cm = 10 N. In answering the questions, make all measurements to the nearest 0.5 cm. Give all directions as bearings to the nearest degree.

1. A + B
2. C – D
3. E + F
4. G – B
5. D + H
6. E – K
7. A + C + E
8. I + J + K
9. E + F – D
10. M – L – H
11. G + D
12. K – C
13. I + B
14. L – A
15. D + J
16. G + 2J
17. M – C
18. I – A
19. K + B
20. L – E



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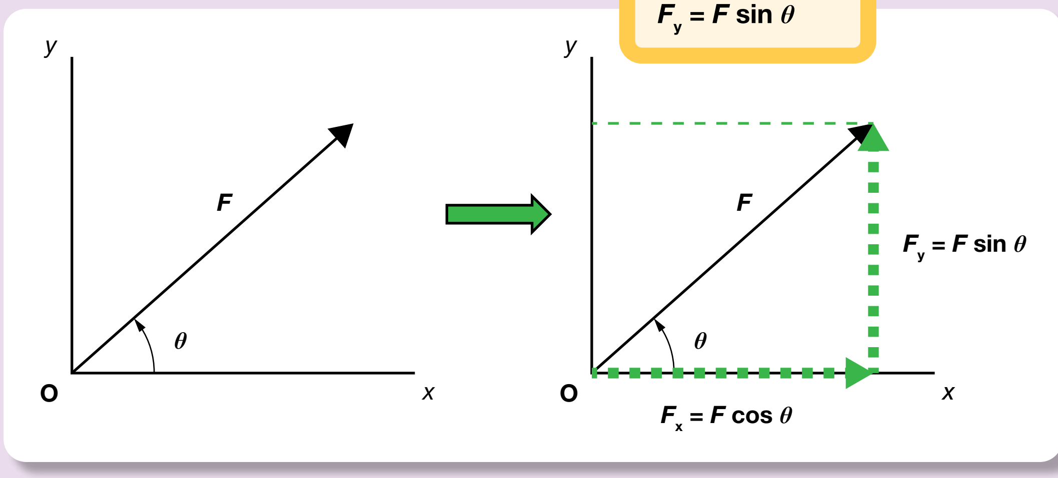
Forces in two dimensions 1

- Like all vector quantities, forces can be resolved into two perpendicular components in the *x* and *y* directions.
- The two force components are given by the equations:

$$F_x = F \cos \theta$$
$$F_y = F \sin \theta$$



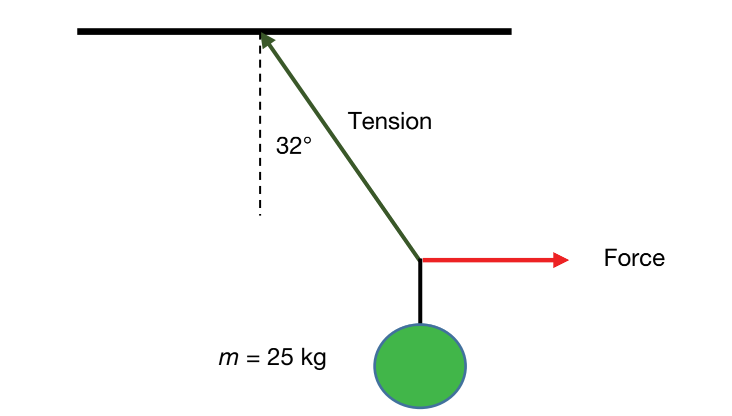
Sample Questions

Each of the following diagrams show masses in static equilibrium. Using your knowledge of components of vectors, analyse each situation to determine the unknown quantities.

1. A mass of 25 kg hangs on a string which is pulled to the side by force *F* until the string makes an angle of 32° to the vertical.

(a) What is the force pulling the supporting string to the side?

(b) What is the tension in the rope?



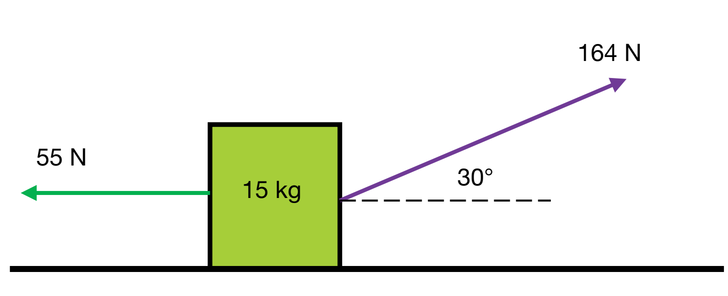
2. The diagram shows the forces acting on a 15 kg mass on a smooth surface.

(a) Calculate the resultant force on the object.

(b) What will be its acceleration?

(c) How fast will it be going after 2.5 s?

(d) Calculate the normal reaction force of the surface on the mass.



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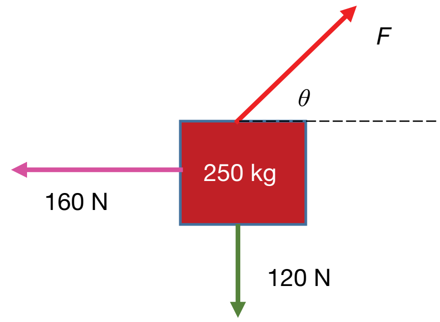
3. Three forces act on a 250 kg block which is in static equilibrium resting on a smooth horizontal surface as shown in the diagram. (*Note*: We are looking at this system from above.)

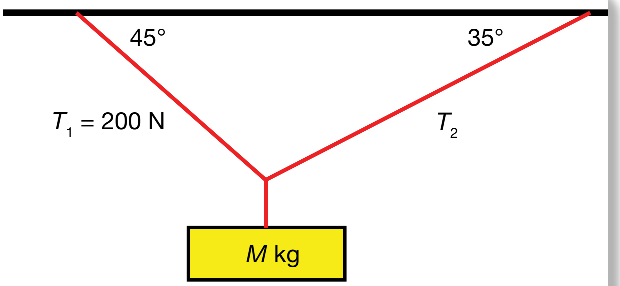
(a) Find the value of the force F and angle θ.

(b) Find the new value for F if the block is replaced by a 125 kg block.



4. An unknown mass hangs from two strings suspended from the ceiling as shown in the diagram.

Find the values of M and T_2 so that the system is in static equilibrium.



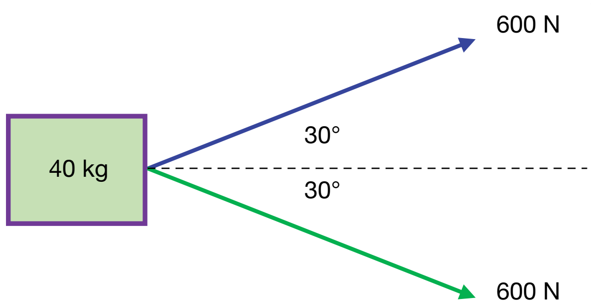
5. Two 600 N forces are applied to a 40 kg at rest object on a frictionless surface as shown in the diagram.

(a) Calculate the resultant force on the object.

(b) What will be its acceleration?

(c) How fast will it be going after 1.5 s?

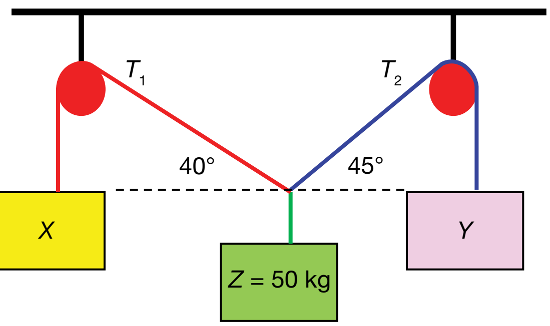
(d) How far does it travel in 2 s?



6. X, Y and Z are the weights of three objects suspended by pulleys as shown. The system is in static equilibrium.

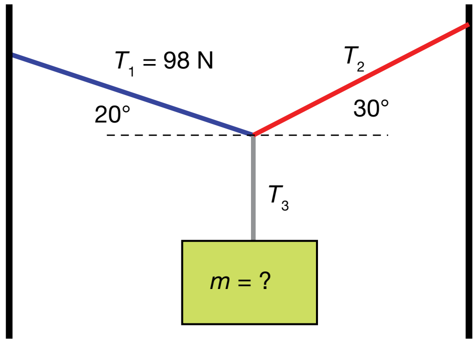
(a) Assuming the pulleys in this system are frictionless and weightless and that Z = 50 kg, what are the values of X and Y?

(b) What are the values of T_1 and T_2 in the ropes?



7. Mass m is suspended by three strings as shown in the diagram. The tension in string 1 is 98 N. The system is in static equilibrium.

What are the values of T_2, T_3 and the mass?



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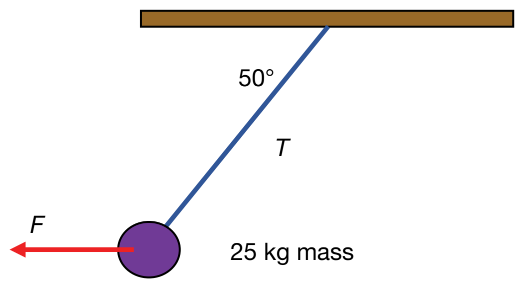
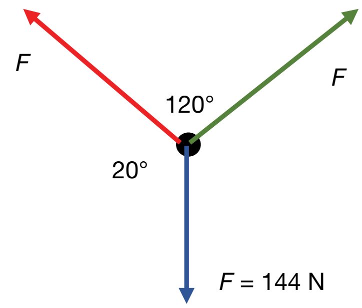
Sample Questions

1. Assuming all the masses in the diagrams are in static equilibrium, determine the value of the resultant force or the force labelled *F* in each situation below.

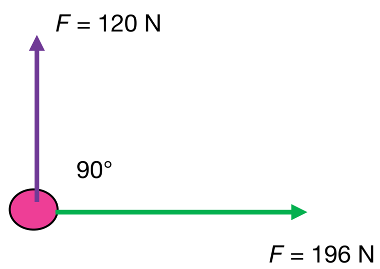
(a) Find value of *F* and *T*.



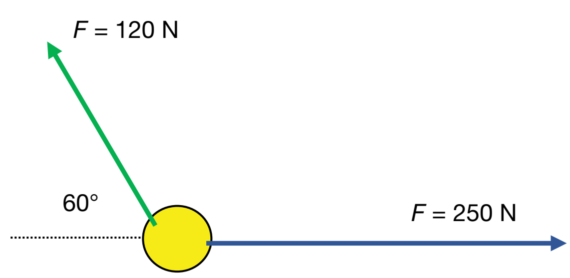
(b) If the two forces are equal, find value of *F*.



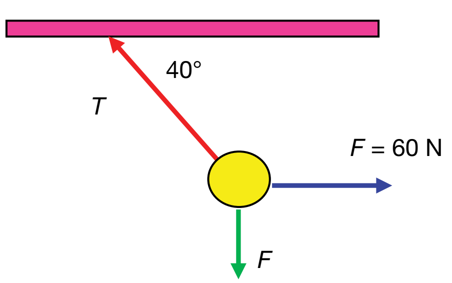
(c) Find resultant force.



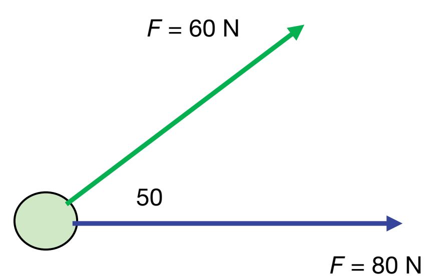
(d) Find resultant force.



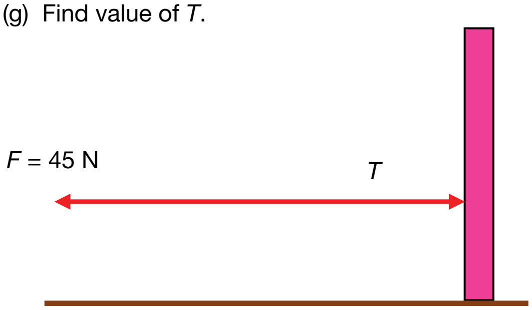
(e) Find value of *T* and the mass of the ball.



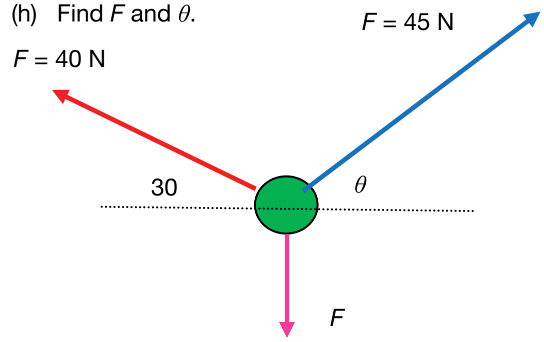
(f) Find resultant force.



(g) Find value of *T*.



(h) Find *F* and θ.



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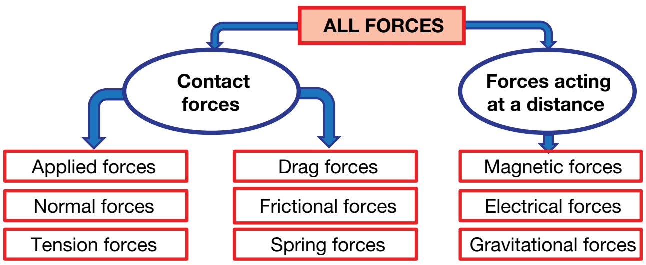
Answers

2.1 Forces, Equilibrium and Newton's First Law

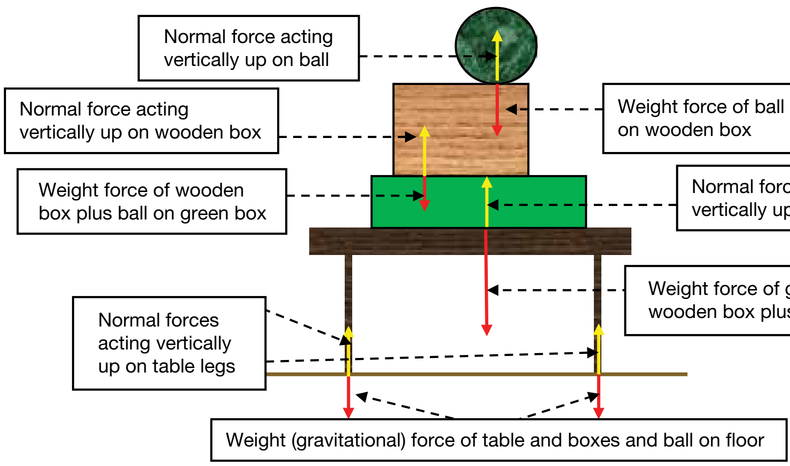
Types of forces

1.



2. The diagram shows a magnified view of the surfaces of the two blocks in contact, showing that at an atomic level, the surfaces are not smooth, and that this is why friction occurs.

3.



4. (a) Mass A has more weight than mass B.

(b) Spring A will have the greater tension (restoring) force within it because it is supporting a greater weight force.

Equilibrium and Newton's first law

1. An object will be in translational equilibrium if it is moving or at rest and there is no resultant force acting on it.

2. An object in static equilibrium is at rest with zero net force acting on it.

3. An object in dynamic equilibrium is moving with constant velocity – no net force acts on it.

4. (a) Static equilibrium

(b) Not in equilibrium

(c) Not in equilibrium

(d) Static equilibrium

(e) Not in equilibrium

(f) Not in equilibrium

(g) Dynamic equilibrium

(h) Static equilibrium

(i) Dynamic equilibrium

(j) Dynamic equilibrium

(k) Dynamic equilibrium