Science Unit 11 Force

Friction and air resistance

When an object slides or tends to slide over a surface, friction acts on the object and opposes the object's sliding motion

- Friction opposes the sliding motion of an object over a surface it is in contact with.
- E.g., finger slides over a smartphone's screen

Extension: Static Friction and Sliding friction

Static friction

When apply a force on an object and the object does not move, friction still exists and we call it static friction

As the object does not move, the net force on the object is zero.

The friction will be equal to the force you apply but in opposite direction.

Sliding friction

When apply a larger force on an object and the object start move, it will have a constant friction and we call it sliding friction.

The factors that will affect the sliding friction are the roughness of the contact surface and the mass of the object.

Friction (contact force)

Air resistance (contact force)

When an object moves in air, an opposing force is called air resistance.

- Air resistance opposes the motion of an object moving in air.
- E.g., Air resistance acts on the bicycle rider and opposes his motion

Reducing friction and air resistance

Using lubricants

The friction between two surfaces can be reduced by applying lubricants.

- E.g., Soapy water, lubricating oil, vaseline

Lubricants can form a layer of lubricating film on the surface of the object, so that the contact area between the surface of the object is reduced, thus reducing the friction between the objects.（润滑油能够在物体表面形成一层润滑膜，使物体表面之间的接触面积减小，从而减少了物体之间的摩擦力）

Separating surfaces using an air cushion

The friction between two surfaces can be reduced by separating them using a layer of air called air cushion

- E.g., Maglev trains and jetfoils

Air cushion reduces the area of contact between the object and the ground, thus reducing the friction force. In addition, the gas in the air cushion can flow, which reduces the air resistance to moving objects across the ground.（气垫可以减少物体与地面之间的接触面积，从而降低摩擦力。另外，气垫中的气体也可以流动，从而使物体在地面上移动时遇到的阻力减小。）

Using rolling objects

Friction can also be reduced with the use of rolling objects.

- E.g., rollers, ball bearing

The contact area of a rolling object is very small. The friction of the object and direction of the rolling object are opposite, so the friction force does not produce much resistance to the motion of the rolling object.（滚动物体的接触面积很小。而且物体的摩擦力和滚动物体移动方向相反，所以摩擦力不会对滚动物体的运动产生太大的阻力。）

Streamlining the shapes of objects

The shape of an object affects the air resistance acting on it.

- The air resistance is reduced if the object has a streamlined shape.
- E.g., high-speed vehicles, airplane, trains

The shape of a streamlined object allows air to flow more smoothly over its surface, reducing the air resistance.（流线型物体的外形设计使得空气在其表面上流动时能够更加顺畅，减少了空气的阻力。）

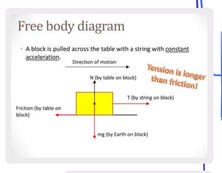
The utility of reducing friction (extension)

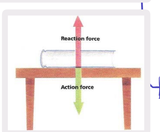
Reduce energy loss; Increase the speed and efficiency of motion and reduce friction; It can reduce the wear and damage of mechanical equipment（减少能量损失；增加运动速度和效率减少摩擦力；可以减少机械设备的磨损和损坏）

Application of using friction and air resistance

Holding objects in position: rock climbing, hold the food using chopsticks

- Preventing slipping: anti-slip strips
- Slowing down moving objects: parachute, brake
- Walking: friction between shoes and ground





Basic ideas of force

- A force is a push or a pull on an object
- We represent forces by drawing arrows
- The arrow is drawn from where the force acts and it points in the direction of force (Practice)
- The longer the arrow, the larger the force

Effect of force

The forces change the speeds of objects

- Change moving objects to move faster or slower
- Change objects at rest to start moving
- Change moving objects to stop

Change the moving direction of object

Change the motion of objects

Measuring the force

Forces can be measured using a spring balance.

- The unit of force is newton (N).
- The spring balance can only measure the pulling forces.

We can also use the force sensor and connected to the data logger to measure the forces. The force sensor can measure both pulling forces and the pushing forces

- (Practice) Using spring balance: We need to use zero adjuster to adjust the position of the scale so that the reading is zero (called zero adjustment)
- (Practice) We draw a graph to show the relationship between the applied force and the (effect of force) e. g., stretched length
  - The applied force (N) is always the independent variable.
  - The independent variable need to draw on x-axis while the dependent variable need to draw on y-axis.

Two types of forces

- Forces can be classified into contact forces and non-contact forces.

Contact forces: Contact forces act on an objects only when the objects are in contact. E.g., supporting force, friction, air resistance, pulling and pushing forces, action and reaction

Non-contact forces: Non-contact forces can exist between objects without any contact (act at a distance) or in contact. E.g., Force of gravity

Balanced forces and unbalanced forces

Free-body diagram

- (Practice) Use free-body diagram to show all the forces acting on an object.

Motion of objects under balanced forces and that under unbalanced forces

Balanced forces: Forces acting on the object can be perfectly balanced by other forces of the same magnitude in the opposite direction called balanced forces

- When balanced forces act on a moving object, the object's speed and direction of motion will remain the same and in uniform motion

Unbalanced forces: Unbalanced forces act on an object, the motion of the object will change

Net force (Extension): When several forces are acting on an object, it is useful to calculate the overall effect of these force. The sum of these forces is called the net force

- Balanced force = Zero net force
- Unbalanced force = The net force is not zero

Newton's first law of motion (Extension): An object remains at rest or moves at a constant speed towards a constant direction if the net force acting on it is zero

Action and reaction

Forces occur in pairs and these pairs of forces are called action-and-reaction pairs.

- The action and reaction act on different objects and in opposite directions and same magnitude
- E.g., force of gravity (action force), supporting force (reaction force)

Motion

Distance (d): The distance of a object travelled

Time (t): The time of the object travelled

Speed (v)

- Speed describes how fast an object moves.
- The speed of an object is the distance travelled by the object per unit time, v=d/t
- The unit of speed:
  - Metre per second (m s^(-1))
  - Kilometre per hour (km h^(-1))
- The faster an object moves, the higher its speed
- The distance travelled by an object during a period of time is necessary for calculate the average speed
- Average speed = distance / time
- (Practice) Need to write the formula before calculate the average speed

Distance-Time Graph

- To represent the motion of an object, draw a distance-time graph for the object
- A distance-time graph shows the distance that an object has travelled at different times.
- When the object is at rest / coming to rest, the distance-time graph is a horizontal line.
- When the object is at a steady speed, the distance-time graph is a straight line with a slope. The higher the speed, the steeper the slope.
- When the object move in uniform motion, the distance-time graph is a straight line. When the object move in non-uniform motion, the distance-time graph is a curve line.

(Practice) Drawing a distance-time graph

- Title E.g., The distance-time graph of the car from time = 0 s to 100 s
- x-axis name with time (unit), draw with a straight line and arrow
- y-axis name with distance (unit), draw with a straight line and arrow
- write the distance and time from the 0 with the same interval
- draw points "x" to represent the data on the graph
- using straight lines to connect the points and "0"

(Practice) Describe the distance-time graph: From time = __ to __, the (object) travelled in a uniform motion / non-uniform motion, the object move in a steady speed / stay at rest / coming to rest, the object move ___ m, the object move in a slower speed / faster speed.

Uniform motion and non-uniform motion

- When an object move at a constant speed and a fixed direction, the object said to be in uniform motion. E.g., The people standing still on an escalator, the dish of sushi on a straight conveyor belt.
- When an object move at a changing speed or changing direction, the object is said to be in non-uniform motion. E.g., when the car is braking, child playing on a swing with direction and speed changing.

Force of gravity

Newton discovered that any two objects attract each other with a force called the force of gravity.

- The force of gravity is an non-contact force.
- The force of gravity exerted by the Earth on an object pulls the object towards the Earth's centre.
- The magnitude of the force of gravity acting on an object depends on the object's mass.
- The greater the mass of the object, the larger the force of gravity.

Weight and mass

The mass of an object measures the amount of matter contains.

- The unit of mass is kilogram (kg) or gram (g)
- The weight of an object on Earth is the force of gravity of the Earth acting on the object.
- Weight can be measured by using a spring balance and its unit is newton.
- The larger the force of gravity acting on an object, the greater its weight.
- The mass of an object is the same in different places because the amount of the matter contained in the object is always the same.
- The weight of an object may change from place to place.
- The mass and the air resistance have a direct proportion.
- The ratio of weight to mass is a constant for any object. The ratio is equal to 9.8 $N\ kg^{-1}$ on Earth. The weight on Moon is about one-sixth of the weight on the Earth 1.63 $N\ kg^{-1}$