# Ordinary Level Physics Long Questions:
# *ACCELERATION, FORCE, MOMENTUM, ENERGY*

### Equations of motion (*vuast*)

**2004 Question 6 [Ordinary Level]**

(i) Define velocity.
(ii) Define acceleration.
(iii) Describe an experiment to measure the velocity of a moving object.
(iv) A cheetah can go from rest up to a velocity of 28 m $s^{-1}$ in just 4 seconds and stay running at this velocity for a further 10 seconds.
Sketch a velocity−time graph to show the variation of velocity with time for the cheetah during these 14 seconds.
(v) Calculate the acceleration of the cheetah during the first 4 seconds.
(vi) Calculate the resultant force acting on the cheetah while it is accelerating.
The mass of the cheetah is 150 kg.
(vii) Name two forces acting on the cheetah while it is running.

**2008 Question 12 (a) [Ordinary Level]**

(i) Define velocity.
(ii) Define acceleration.
(iii) A speedboat starts from rest and reaches a velocity of 20 m $s^{-1}$ in 10 seconds.
It continues at this velocity for a further 5 seconds.
The speedboat then comes to a stop in the next 4 seconds.
Draw a velocity-time graph to show the variation of velocity of the boat during its journey.
(iv) Use your graph to estimate the velocity of the speedboat after 6 seconds.
(v) Calculate the acceleration of the boat during the first 10 seconds.
(vi) What was the distance travelled by the boat when it was moving at a constant velocity?

**2010 Question 12 (a) [Ordinary Level]**

(i) A cyclist on a bike has a combined mass of 120 kg.
The cyclist starts from rest and by pedalling applies a net force of 60 N to move the bike along a horizontal road.
Calculate the acceleration of the cyclist
(i) Calculate the maximum velocity of the cyclist after 15 seconds.
(ii) Calculate the distance travelled by the cyclist during the first 15 seconds.
(iii) The cyclist stops peddling after 15 seconds and continues to freewheel for a further 80 m before coming to a stop. Why does the bike stop?
(iv) Calculate the time taken for the cyclist to travel the final 80 m.

**2014 Question 12 (a) [Ordinary Level]**

(i) Explain the distinction between speed and velocity.

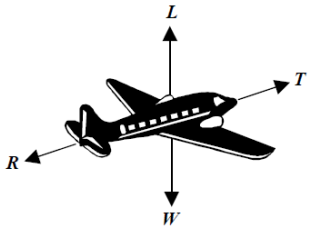
A bus leaves a bus stop and accelerates from rest at 0.5 m $s^{-2}$ to reach a speed of 15 m $s^{-1}$.
It then maintains this speed for 100 seconds. When it approaches the next stop, the driver applies the brakes uniformly to bring the bus to a stop in 20 seconds.

(ii) Calculate the time it took the bus to reach its top speed.
(iii) Calculate the distance it travelled while at its top speed.
(iv) Calculate the acceleration required to bring the bus to a stop.
(v) Sketch a velocity-time graph of the bus journey.

## Force, gravity and acceleration

**2002 Question 6 [Ordinary Level]**

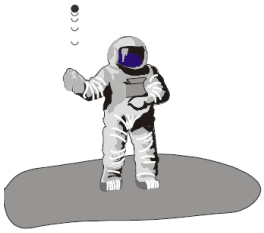
(i) Define (i) velocity, (ii) acceleration.
(ii) Copy and complete the following statement of Newton's first law of motion.
"An object stays at rest or moves with constant velocity (i.e. it does not accelerate) unless……."
The diagram shows the forces acting on an aircraft travelling horizontally at a constant speed through the air.
L is the upward force acting on the aircraft.
W is the weight of the aircraft.
T is the force due to the engines.
R is the force due to air resistance.




(iii) What happens to the aircraft when the force L is greater than the weight of the aircraft?
(iv) What happens to the aircraft when the force T is greater than the force R?
(v) The force T exerted by the engines is 20 000 N.
Calculate the work done by the engines while the aircraft travels a distance of 500 km.
(vi) The aircraft was travelling at a speed of 60 m $s^{-1}$ when it landed on the runway. It took two minutes to stop. Calculate the acceleration of the aircraft while coming to a stop.
(vii) The aircraft had a mass of 50 000 kg. What was the force required to stop the aircraft?
(viii) Using Newton's first law of motion, explain what would happen to the passengers if they were not wearing seatbelts while the aircraft was landing.

**2003 Question 6 [Ordinary Level]**

(i) Copy and complete the following statement of Newton's law of universal gravitation.
"Any two point masses attract each other with a …… which is proportional to the product of their ……... and inversely proportional to the ……..……..……. between them."
(ii) What is meant by the term acceleration due to gravity?
(iii) An astronaut of mass 120 kg is on the surface of the moon, where the acceleration due to gravity is 1.6 m $s^{-2}$. What is the weight of the astronaut on the surface of the moon?



(iv) The astronaut throws a stone straight up from the surface of the moon with an initial speed of 25 m $s^{-1}$. Describe how the speed of the stone changes as it reaches its highest point.
(v) Calculate the highest point reached by the stone.
(vi) Calculate how high the astronaut can throw the same stone with the same initial speed of 25 m $s^{-1}$ when on the surface of the earth, where the acceleration due to gravity is 9.8 m $s^{-2}$.
(vii) Why is the acceleration due to gravity on the moon less than the acceleration due to gravity on the earth?

**2006 Question 6 [Ordinary Level]**

(i) Define the term force and give the unit in which force is measured.
(ii) Force is a vector quantity. Explain what this means.
(iii) Newton's law of universal gravitation is used to calculate the force between two bodies such as the moon and the earth.
Give two factors which affect the size of the gravitational force between two bodies.
(iv) Explain the term acceleration due to gravity, $g$.
(v) An astronaut carries out an experiment to measure the acceleration due to gravity on the surface of the moon.
He drops an object from a height of 1.6 m above the surface of the moon and the object takes 1.4 s to fall.
Use this data to show that the acceleration due to gravity on the surface of the moon is 1.6 m $s^{-2}$.
(vi) The astronaut has a mass of 120 kg. Calculate his weight on the surface of the moon.
(vii) Why is the astronaut's weight greater on earth than on the moon?
(viii) The earth is surrounded by a layer of air, called its atmosphere. Explain why the moon does not have an atmosphere.

**2008 Question 6 [Ordinary Level]**

The weight of an object is due to the gravitational force acting on it.
Newton investigated the factors which affect this force.
(i) Define force and give the unit of force.
(ii) State Newton's law of universal gravitation.
(iii) Calculate the acceleration due to gravity on the moon.
The radius of the moon is $1.7 \times 10^6$ m and the mass of the moon is $7 \times 10^{22}$ kg.
(iv) A lunar buggy designed to travel on the surface of the moon had a mass of 2000 kg when built on the earth.
What is the weight of the buggy on earth?
(v) What is the mass of the buggy on the moon?
(vi) What is the weight of the buggy on the moon?
(vii) A powerful rocket is required to leave the surface of the earth.
A less powerful rocket is required to leave the surface of the moon.
Explain why.

**2012 Question 6 [Ordinary Level]**

(i) What is meant by the term 'acceleration due to gravity'?
(ii) A spacecraft of mass 800 kg is on the surface of the moon, where the acceleration due to gravity is 1.6 m $s^{-2}$.
Compare the weight of the spacecraft on the surface of the moon with its weight on earth, where the acceleration due to gravity is 9.8 m $s^{-2}$.
(iii) The module of the spacecraft has a mass of 600 kg, when it is launched vertically from the surface of the moon with its engine exerting an upward force of 2000 N.
Draw a diagram showing the forces acting on the module at lift-off.
(iv) What is the resultant force on the module?
(v) Calculate the acceleration of the module during lift-off.
(vi) Calculate the velocity of the module, 20 seconds after lift-off.
(vii) Would the engine of the module be able to lift it off the earth's surface?
(viii) Justify your answer in terms of the forces acting on the module.
(ix) Why is the acceleration due to gravity on the moon less than the acceleration due to gravity on earth?
(x) Suggest a reason why the module of the spacecraft when launched from the moon does not need a streamlined shape like those that are launched from earth.

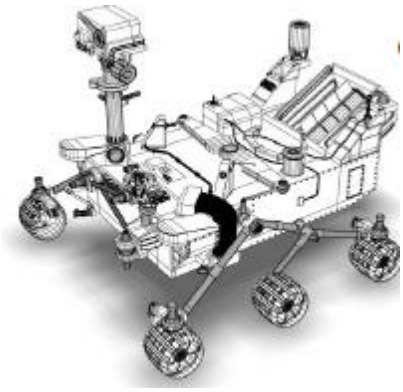
**2014 Question 6 [Ordinary Level]**

(i) Sir Isaac Newton deduced that the weight of an object is due to the force of gravity.
Define force and give the unit of force.

(ii) State Newton's law of universal gravitation.

(iii) Use the equation below, which is from page 56 of the *Formulae and Tables* booklet, to calculate, to one decimal place, the acceleration due to gravity on Mars.
The radius of Mars is $3.4 \times 10^6$ m and the mass of Mars is $6.4 \times 10^{23}$ kg.

$$g = \frac{GM}{d^2}$$



(iv) In August 2012 the *Curiosity* rover landed on Mars.
The wheels of the rover are not as strong as the wheels that would be needed if the rover was to be used on Earth.
Give a reason for this.

(v) The *Curiosity* rover was built on Earth to travel on the surface of Mars.
The rover has a mass of 899 kg.
Calculate the weight of *Curiosity* on Earth

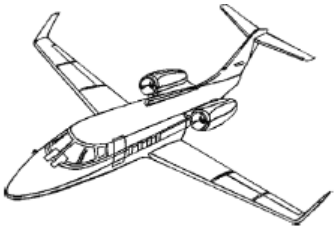
(vi) Calculate the mass of *Curiosity* on Mars

(vii) Calculate the weight of *Curiosity* on Mars.

(viii) The *Curiosity* rover communicates with Earth using radio waves, which are part of the electromagnetic spectrum. Name one other part of the electromagnetic spectrum.
(acceleration due to gravity, $g = 9.8$ m s$^{-2}$)

## Momentum

**2013 Question 6 [Ordinary Level]**



Define momentum,
Define force.
State the principle of conservation of momentum.
Explain how the principle of conservation of momentum applies in the case of a jet engine moving an aircraft.

A truck of mass 5000 kg is moving with a velocity 10 m s$^{-1}$ when it collides with a stationary car with a mass of 1000 kg. The truck and the car then move off together.


(i) Calculate the momentum of the truck and the car before the collision.

(ii) What is the momentum of the combined vehicles after the collision?

(iii) Calculate the velocity of the combined vehicles after the collision.

(iv) What is the momentum of the truck after the collision?

(v) If the collision between the truck and the car takes 0.3 seconds, calculate the force exerted by the truck on the car.

(vi) When the truck hits the back of the car the driver's airbag inflates. The airbag deflates when it is hit by the driver's head. Explain why the airbag reduces the risk of injury to the driver.

**2007 Question 12 (a) [Ordinary Level]**

(i) State the principle of conservation of momentum.

(ii) A rocket is launched by expelling gas from its engines.
Use the principle of conservation of momentum to explain why a rocket rises.


(iii) The diagram shows two shopping trolleys each of mass 12 kg on a smooth level floor.
Trolley A moving at 3.5 m s$^{-1}$ strikes trolley B, which is at rest.
After the collision both trolleys move together in the same direction.
Calculate the initial momentum of trolley A

(iv) Calculate the common velocity of the trolleys after the collision.

**2004 Question 12 (a) [Ordinary Level]**

(i) Define momentum. Give the unit of momentum.

(ii) State the principle of conservation of momentum.

(iii) The diagram shows a child stepping out of a boat onto a pier.
The child has a mass of 40 kg and steps out with an initial velocity of 2 m s$^{-1}$ towards the pier.
The boat, which was initially at rest, has a mass of 50 kg.
Calculate the initial velocity of the boat immediately after the child steps out.

## Work, Energy and Power

**2005 Question 11 [Ordinary Level]**

Read the following passage and answer the accompanying questions.

There are different forms of energy. Fuels such as coal, oil and wood contain chemical energy. When these fuels are burnt, the chemical energy changes into heat and light energy. Electricity is the most important form of energy in the industrialised world, because it can be transported over long distances via cables. It is produced by converting the chemical energy from coal, oil or natural gas in power stations.

In a hydroelectric power station the potential energy of a height of water is released as the water flows through a turbine, generating electricity.

Energy sources fall into two broad groups: renewable and non-renewable. Renewable energy sources are those which replenish themselves naturally and will always be available – hydroelectric power, solar energy, wind and wave power, tidal energy and geothermal energy. Non-renewable energy sources are those of which there are limited supplies and once used are gone forever. These include coal, oil, natural gas and uranium.

(Adapted from the Hutchinson Encyclopaedia of Science, 1998).

*(a)* Define energy.

*(b)* What energy conversion takes place when a fuel is burnt?

*(c)* Name one method of producing electricity.

*(d)* Give one factor on which the potential energy of a body depends.

*(e)* What type of energy is associated with wind, waves and moving water?

*(f)* Give one disadvantage of non-renewable energy sources.

*(g)* How does the sun produce heat and light?

*(h)* In Einstein's equation $E = mc^2$, what does $c$ represent?

**2011 Question 6 [Ordinary Level]**

(i) State Newton's first law of motion.

(ii) A car of mass 1400 kg was travelling with a constant speed of 15 m $s^{-1}$ when it struck a tree and came to a complete stop in 0.4 s.
Draw a diagram of the forces acting on the car before it hit the tree.

(iii) Calculate the acceleration of the car during the collision.

(iv) Calculate the kinetic energy of the moving car before it struck the tree.

(v) What happened to the kinetic energy of the moving car?

(vi) A back seat passenger could injure other occupants during a collision.
Explain, with reference to Newton's laws of motion, how this could occur.

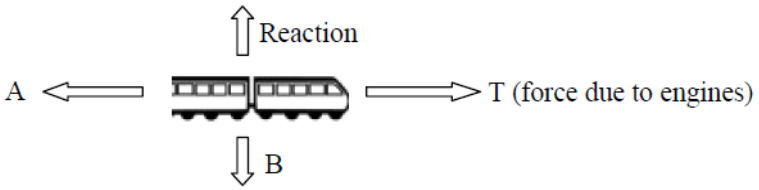
(vii) How is this risk of injury minimised?

**2009 Question 6 [Ordinary Level]**

(i) Define velocity.

(ii) Define friction.

(iii) The diagram shows the forces acting on a train which was travelling horizontally.
A train of mass 30000 kg started from a station and accelerated at 0.5 m $s^{-2}$ to reach its top speed of 50 m $s^{-1}$ and maintained this speed for 90 minutes.




As the train approached the next station the driver applied the brakes uniformly to bring the train to a stop in a distance of 500 m.
Calculate how long it took the train to reach its top speed.

(iv) Calculate how far it travelled at its top speed.

(v) Calculate the acceleration experienced by the train when the brakes were applied.

(vi) What was the force acting on the train when the brakes were applied?

(vii) Calculate the kinetic energy lost by the train in stopping.

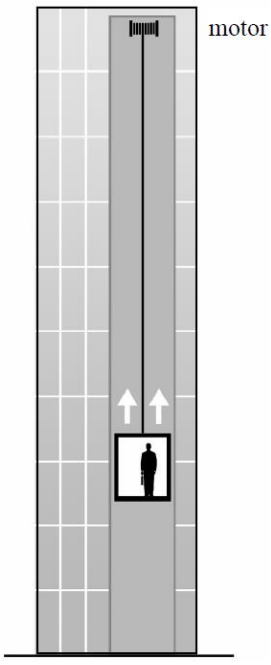
(viii) What happened to the kinetic energy lost by the train?

(ix) Name the force A and the force B acting on the train, as shown in the diagram.

(x) Describe the motion of the train when the force A is equal to the force T.

(xi) Sketch a velocity-time graph of the train's journey.

**2007 Question 6 [Ordinary Level]**




(i) Define work and give the unit of measurement.

(ii) Define power and give the unit of measurement.

(iii) What is the difference between potential energy and kinetic energy?

(iv) An empty lift has a weight of 7200 N and is powered by an electric motor.
The lift takes a person up 25 m in 40 seconds.
The person weighs 800 N.
Calculate the total weight raised by the lift's motor.

(v) Calculate the work done by the lift's motor.

(vi) Calculate the power output of the motor.

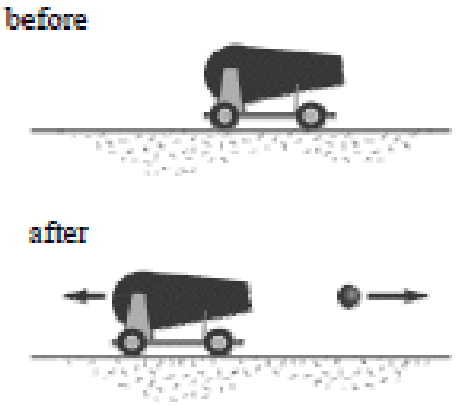
(vii) Calculate the energy gained by the person in taking the lift.

(viii) If instead the person climbed the stairs to the same height in 2 minutes, calculate the power generated by the person in climbing the stairs.

(ix) Give two disadvantages of using a lift.

## Kinetic Energy and Momentum

**2012 Question 12 (a) [Ordinary Level]**




(i) State the principle of conservation of momentum.

(ii) A cannon of mass 1500 kg containing a cannonball of mass 80 kg was at rest on a horizontal surface as shown.
The cannonball was fired from the cannon with an initial horizontal velocity of 60 m $s^{-1}$ and the cannon recoiled.
Calculate the recoil velocity of the cannon

(iii) Calculate the kinetic energy of the cannon as it recoils.

(iv) Why did the cannon recoil?

(v) Why will the cannon come to a stop in a shorter distance that the cannonball?

**2010 Question 6 [Ordinary Level]**

(i) Define momentum

(ii) Define kinetic energy

(iii) State the principle of conservation of momentum.

(iv) Explain how this principle applies in launching a spacecraft.

(v) An ice skater of mass 50 kg was moving with a speed of 6 m $s^{-1}$ then she collides with another skater of mass 70 kg who was standing still. The two skaters then moved off together.
Calculate the momentum of each skater before the collision?

(vi) What is the momentum of the combined skaters after the collision?

(vii) Calculate the speed of the two skaters after the collision.

(viii) Calculate the kinetic energy of each skater before the collision.

(ix) Calculate the kinetic energy of the pair of skaters after the collision.

(x) Comment on the total kinetic energy values before and after the collision.

**2015 Question 6 [Ordinary Level]**

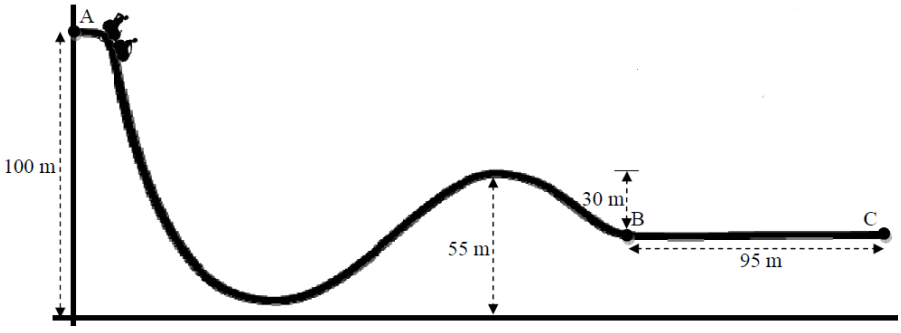
(i) Define potential energy.

(ii) Define kinetic energy.

(iii) State the principle of conservation of energy.

(iv) Explain how the principle applies to a roller-coaster.

A roller-coaster car of mass 850 kg is released from rest at point A of the track, as shown in the diagram.




(v) Calculate the difference in height between point A and point B.

(vi) Calculate the change in the potential energy of the car between A and B.

(vii) Write down the kinetic energy of the car at point B, assuming there is no friction and no air resistance.

(viii) Calculate its velocity at point B.

(ix) The brakes are applied at point B and the car comes to a stop at point C.
Calculate the deceleration of the car between B and C.

(x) Calculate the average force required to bring the car to a stop.

(acceleration due to gravity, $g$ = 9.8 m $s^{-2}$)