RRB

Railway Recruitment Board

Junior Engineer

CBT 1

Computer Based Test - Stage 1

- General Science
- General Awareness

Comprehensive Theory *with* Practice Questions
& Previous Years' Solved Questions

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RRB-Junior Engineer : General Science & General Awareness

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Preface

B. Singh (Ex. IES)

The post of Railway Recruitment Board-Junior Engineer has always been preferred by Engineers due to job stability. Indian Railways is one of the biggest Government employers in India. With the exam being just a few months away, it is time for the candidates planning to appear for the exam to pull up their socks and start their RRB-JE preparation.

The RRB-JE exam is conducted in two stages as shown in table given below.

Papers	**Subjects**	**Maximum Marks**	**Duration**
CBT-1 : Objective Type	(i) Mathematics	30 Marks	90 Minutes
	(ii) General Intelligence and Reasoning	25 Marks	
	(iii) General Awareness	15 Marks	
	(iv) General Science	30 Marks	
	Total	**100 Marks**	
CBT-2 : Objective Type	(i) General Awareness	15 Marks	120 Minutes
	(ii) Physics and Chemistry	15 Marks	
	(iii) Basics of Computers and Applications	10 Marks	
	(iv) Basics of Environment and Pollution Control	10 Marks	
	(v) Technical Abilities (viz, CE, ME, EE, EC, CS etc)	100 Marks	
	Total	**150 Marks**	
Note: There shall be negative marking for incorrect answers in CBTs. Each question carries 1 mark and 1/3rd of the marks alloted for each question shall be deducted for each wrong answer. Candidates shortlisted in Stage 1 will be called for Stage 2.			

This book comprises both the General Science & General Awareness subjects. Besides, previous years' RRB-JE questions have been also included in a separate section. MADE EASY has taken due care to present detailed theory and MCQs without compromising the accuracy of answers.

Apart from Railway Recruitment Board-Junior Engineer Exam, this book is also useful for Public Sector Examinations and other competitive examinations for engineering graduates. I hope this book will prove as an important tool to succeed in RRB-JE and other competitive exams.

I have true desire to serve student community by providing good source of study materials and quality guidance. Any suggestion from the readers for improvement of this book is most welcome.

With Best Wishes

B. Singh

CMD, MADE EASY

Exam Syllabus

(Computer Based Test 2019-First Stage)

Mathematics: Number systems, BODMAS, Decimals, Fractions, LCM and HCF, Ratio and Proportion, Percentages, Mensuration, Time and Work, Time and Distance, Simple and Compound Interest, Profit and Loss, Algebra, Geometry, Trigonometry, Elementary Statistics, Square Root, Age Calculations, Calendar & Clock, Pipes & Cistern.

General Intelligence and Reasoning: Analogies, Alphabetical and Number Series, Coding and Decoding, Mathematical operations, Relationships, Syllogism, Jumbling, Venn Diagram, Data Interpretation and Sufficiency, Conclusions and Decision Making, Similarities and Differences, Analytical reasoning, Classification, Directions, Statement – Arguments and Assumptions etc.

General Awareness: Knowledge of Current affairs, Indian geography, culture and history of India including freedom struggle, Indian Polity and constitution, Indian Economy, Environmental issues concerning India and the World, Sports, General scientific and technological developments etc.

General Science: Physics, Chemistry and Life Sciences (up to 10th Standard CBSE syllabus).

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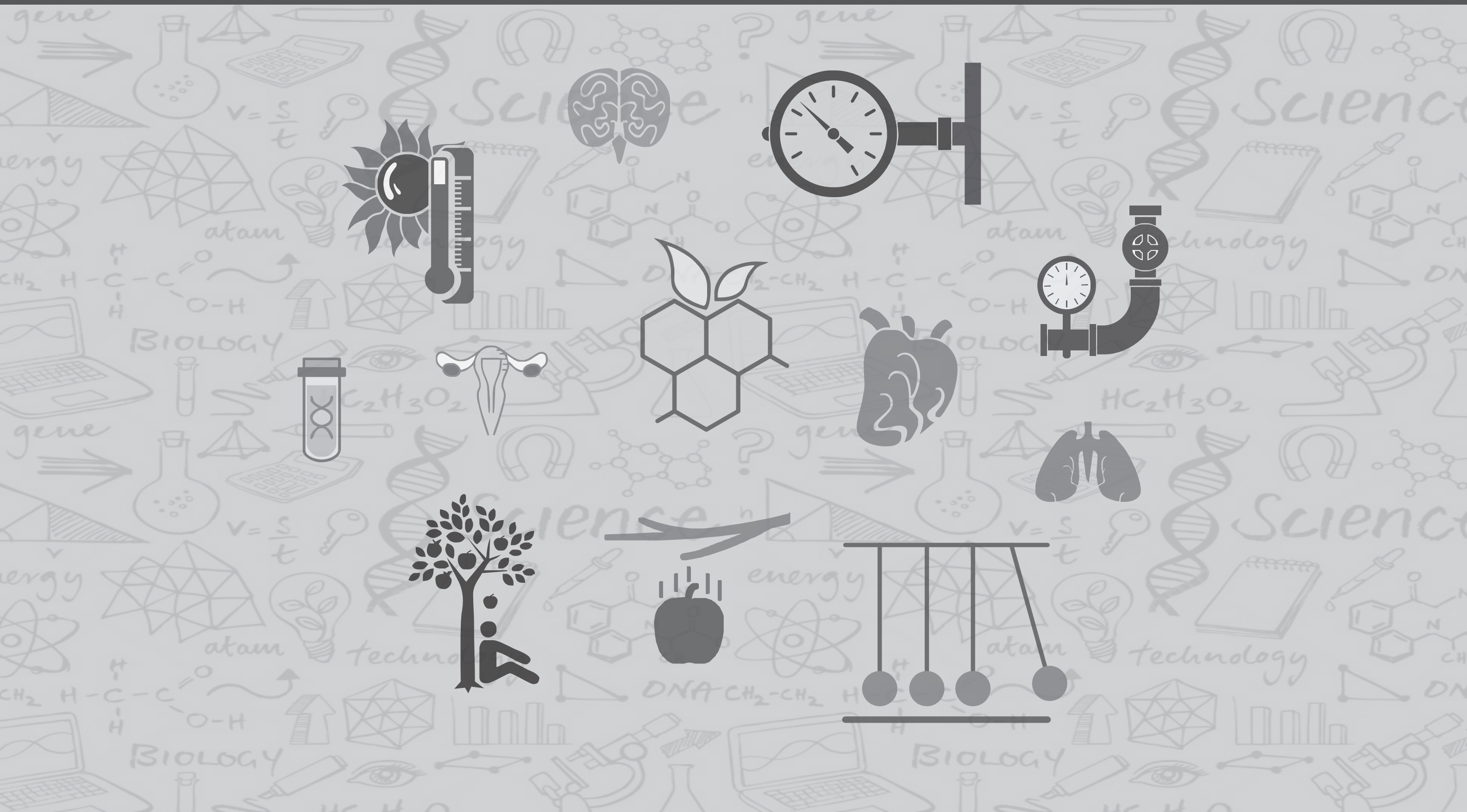
Railway Recruitment Board (RRB) | Junior Engineer Examination



Physics

1
Chapter

Physics is a branch of science which is concerned with all aspects of nature on both the microscopic and macroscopic level. Its scope of study encompasses not only the behavior of objects under the action of forces but also the nature of gravitational, electromagnetic, nuclear forces among others.
The ultimate objective of physics is to formulate comprehensive principles that bring together and explain all such phenomena.

UNITS & MEASUREMENT

Unit & Measurement

- Unit is the chosen standard used for measuring a physical quantity.
- There are basically two types of unit:
  1. **Fundamental Unit:** These units are a set of measurements, defined arbitrarily and from which other units are derived. Examples: meter, kilogram, second, etc.
     The fundamental unit of some of the physical quantities are given below:

International System of Units (S.I.)		
Physical	**Fundamental**	**Symbol**
Mass	Kilogram	kg
Length	Metre	m
Time	Second	s
Temperature	Kelvin	K
Electric-current	Ampere	A
Luminous intensity	Candela	Cd
Quantity of matter	Mole	mol

Systems of units	Length	Mass	Time
C.G.S. System	Centimetre	Gram	Second
F.P.S. System	Foot	Pound	Second
M.K.S. System	Metre	Kilogram	Second

  2. **Derived Unit:** All the units which are expressed in terms of fundamental units are known as derived units. Examples: Newton, Joule, etc.
- Internationally, there are four types of unit systems. These are:
  1. **S.I. Units/System:** It is the modern form of the metric system, and is the most widely used system of measurement. It comprises a coherent system of units of measurement built on seven base units namely kilogram, meter, second, candela, ampere, kelvin and mol.
  2. **CGS System:** The centimeter-gram-second (CGS) system of units is a variant of the metric system based on centimetre as the unit of length, gram as unit of mass, and the second as the unit of time.
  3. **FPS System:** The foot-pound-second (FPS) system is a system of units built on three fundamental units: the foot for length, the pound for mass and the second for time.
  4. **MKS System:** The MKS system of units is a physical system of units that expresses any given measurement using base units of the metre, kilogram, and second.

MOTIONS

Basics of Motion

A body is said to be in motion if it changes its position with respect to its surroundings as time goes on. A body is said to be at rest if it does not change its position with time, with respect to its surroundings.

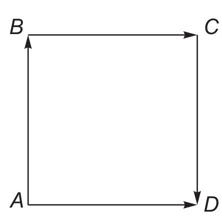
Types of Motion

(i) When a particle or a body moves along a straight path, its motion is Rectilinear or translatory motion.

(ii) When a particle or a body moves in a circular path, its motion is circular motion. When a body spins about its own axis, it is said to be in rotational motion.

(iii) When a body moves to and fro or back and forth repeatedly about a fixed point in a definite interval of time, it is said to be in vibrational or oscillatory motion.

The path travelled by an object during its motion is called trajectory. The actual path length during the motion is called distance and, the straight distance between the initial and final position of the motion in a particular direction is called displacement.



Let a particle travel, starting from point *A* and go to point *D* along the path *ABCD* in a given interval of time. The total path length (= *AB* + *BC* + *CD*) is the distance travelled and the shortest path length (*AD*) in the direction *A* to *D* is the displacement within the same time-interval.

Speed

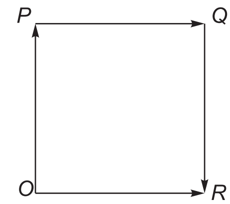
The time rate of change of position of an object in any direction i.e. the rate of change of distance of an object with respect to time is known as speed.

$$\text{Speed} = \frac{\text{displacement}}{\text{time taken}}$$

Velocity

The rate of change of displacement of an object with respect to time is known as velocity.

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}}$$



Let a square *OPQR* of side length 2 metre. A particle travels along its side starting from *O* to *R* via *P* and *Q*. It takes a total time of 2 seconds. The total distance travelled is *OP* + *PQ* + *QR* = 2 + 2 + 2 = 6 metres whereas the total displacement is *OR* = 2 metres. Hence

$$\text{Average Speed} = \frac{\text{distance}}{\text{time}} = \frac{6}{2} = 3 \text{ m/s}$$

$$\text{Average Velocity} = \frac{\text{displacement}}{\text{time}} = \frac{2}{2} = 1 \text{ m/s}$$

Acceleration

The rate of change of velocity with respect to time is called acceleration.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{time taken}}$$

When a body completes equal displacement in equal interval of time, its velocity is constant and hence, it does not have an acceleration. When a body shows equal change in velocity in equal interval of time its velocity is not constant but it has a constant acceleration.

Equation of Motion

For a body moving with a uniform velocity

If a body completes a displacement '*S*' in time '*t*' with a uniform velocity '*V*', then,

Displacement = velocity × time

or $S = vt$ ...(i)

For a body moving with a uniform acceleration

If a body starting with an initial velocity '*u*' moves with a uniform acceleration '*a*' for a time '*t*' and attains a final velocity '*v*' after travelling a displacement '*s*' then,

$$S = ut + \frac{1}{2}at^2 \quad \text{....(iii)}$$

$$v^2 = u^2 + 2as \quad \text{...(iv)}$$

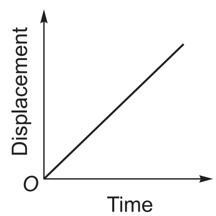
When the velocity of a body increases, it has a positive acceleration and when the velocity decreases, it has a negative acceleration.

This negative acceleration is called deceleration or retardation. When a body is released from a height, its velocity increases by 9.8 m/s in every second and when a body is thrown above the earth's surface, its velocity decreases by 9.8 m/s in every second. This change in velocity every second is called acceleration due to gravity which is denoted by 'g'. Its average value at the earth's surface is 9.8 m/s². It is always directed towards the centre of the earth because of the gravitational pull. For a freely falling body, its acceleration is 9.8 m/s².

Position (Displacement)-Time Graphs

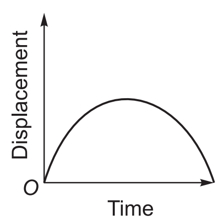
For a body moving with a uniform velocity

This graph comes as a straight line because in a uniform velocity the particle completes equal displacement in an equal interval of time.



For the motion of a body thrown vertically upwards

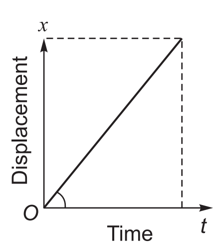
When the body moves up, its velocity continuously decreases due to gravity and finally becomes zero at the maximum height. Then, the body falls with an increasing velocity.



The slope of the position time graph is equal to the uniform velocity.

$$\text{Slope} = \frac{\text{Displacement}}{\text{Time}}$$

or $$V = \frac{x}{t}$$



Velocity-time Graph

For a uniformly accelerated motion the velocity-time graph is a straight line. The area under the velocity-time graph is equal to displacement.

$\therefore$ Displacement = Area under velocity time graph

$$= \text{Area of } \Delta OAB = \frac{1}{2} \times AB \times OB$$

Where $\frac{AB}{2}$ = Average velocity (Var.)

$$= \frac{\text{Initial velocity+Final velocity}}{2}$$

or $V_{av} = \frac{u+v}{2}$ and OB = time (t)

$$\therefore \quad S = \left(\frac{u+v}{2}\right)t$$

$$\therefore \quad V = u + at$$

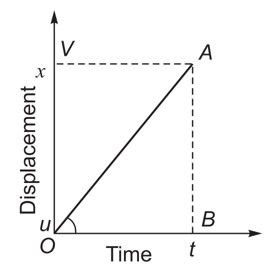
The slope of the velocity time graph is equal to acceleration.

In the figure, Slope = $\frac{AB}{OB}$ = acceleration

and OB = time (t)

$$\therefore \quad a = \frac{v-u}{t}$$

or, $$V = u + at$$



Physical Quantities

Vectors

They have a definite magnitude and a definite direction, e.g. displacement, velocity, acceleration, force etc.

Scalars

They have definite magnitudes only and not direction. e.g. distance, speed, work, energy, power, electric charge etc.

Tensors

They have different magnitudes in different directions, e.g. Moment of interia, stress etc.

In a motion, a body can have a constant speed but variable velocity like the motion of a body along a circular path. A particle may have zero displacement and zero velocity but non-zero distance and speed. When a body completes one revolution along a circular path in a given time period, the net displacement and velocity of the body will be zero but the distance and speed of the body must be non-zero.

The velocity and acceleration of a body may not necessarily be in the same direction and may not be zero simultaneously. The body in equilibrium may be at rest or may move with a constant velocity.

When a body is thrown upwards, it will go vertically until its vertical velocity becomes zero and it will return to the ground with the same velocity with which it was thrown.

When a body is thrown horizontally from a height or dropped from the same height in both cases it will be reaching to the ground simultaneously because in both the cases the body will be acted upon by the same vertically downward acceleration due to gravity (g).

A physical quantity having direction may or may not be a vector e.g. time, pressure, current-electricity, surface-tension etc. They have direction but are not vectors.

Linear-Momentum

It is the quantity of motion which a body possesses and is measured as the product of the mass and velocity of the body.

Linear momentum = mass × velocity

Impulse

The total change in momentum is called the impulse. If a very large force acts for a very small time, the product of force and the time is equal to the impulse.

Inertia

The inability of a body to change by itself its state of rest or state of uniform motion along a straight line is called inertia of the body.

The inertia of a body is measured by its mass. Heavier the body, greater is the force required to change its state and hence greater is its inertia. Inertia of a body may be inertia of rest, inertia of motion or inertia of direction.

Newton's Laws of Motion

First Law of Motion

Every body continues to be in a state of rest or uniform motion in a straight line, except in so far as it may be compelled by force to change that state.'

Newton's first law of motion defines inertia.

1. **Inertia of Rest :** The inability of a body to change by itself its state of rest.
   - When a branch of a fruit tree is shaken, the fruits fall down. This is because the branch comes in motion and the fruits tend to remain at rest. Hence, they get detached.
   - The dirt particles in a durree fall off if it is stricken by a stick. This is because the striking sets the durree in motion whereas the dirt-particles tend to remain at rest and hence fall.
   - When a train starts suddenly, the passenger sitting inside tends to fall backwards. This is so because the lower part of the passenger's body starts moving with the train but the upper part tends to remain at rest.
   - If a smooth paper having a coin on it placed on a table is suddenly drawn, the coin remains at the same place on the table due to inertia of rest.
   - When a horse starts suddenly, the rider tends to fall backwards due to inertia of rest
2. **Intertia of Motion :** The inability of a body to change by itself its state of uniform motion.
   - When a horse at full gallop stops suddenly, the rider on it falls forward because of inertia of motion of the upper part of the rider's body.
   - When an athelete takes a long jump, he runs first for a certain distance before the jump. This is because his feet come to rest on touching the ground and the remaining body continues to move owing to inertia of motion.
   - When train stops suddenly, a passenger sitting inside tends to fall forward. It happens because the lower part of the passenger's body comes to rest with the train but the upper part tends to continue its motion due to inertia of motion.
   - A person jumping out of a speeding train may fall forward due to inertia of motion of his body. Hence, he should run a few steps on the platform in the direction of motion of train.
3. **Inertia of Direction :** The inability of a body to change by itself its direction of motion.
   - The wheels of any moving vehicle throw out mud, if any, tangentially, due to the inertia of direction. The mud-guards over the wheels stop this mud, protecting the clothes, etc. of the person sitting on the bike.
   - Use of an umbrella to protect us from rain is based on the property of inertia of direction because the rain drops cannot change their direction of motion.
   - When a bus or a car rounds a curve suddenly, the person sitting inside is thrown outwards. It happens so because the person tries to maintain his direction of motion due to directional inertia while the vehicle turns.

- When a knife is sharpened by pressing it against a grinding stone, the sparks fly off tangentially because of the inertia of direction.
- When a stone tied to one end of a string is whirled and the string breaks suddenly, the stone spins off along the tangent of its circular path. It happens so because of the pull in the string was forcing the stone to move in a circle. As soon as the string breaks, the pull disappears. The stone becomes free and in a bid to move along the straight line flies off tangentially.

Second Law of Motion

The rate of change of linear momentum of a body is directly proportional to the external force applied on the body and this change takes place always in the direction of the applied force'.

The second law gives us a measure of force. When a force is applied on a body, its momentum and hence, velocity change. The change in velocity produces an acceleration in the body. The rate of change of linear momentum with time is equal to the product of the mass of the body and its acceleration which measures the magnitude of the applied force i.e.

$$\text{Force} = \frac{\text{Change in linear momentum}}{\text{time interval}}$$

$$= \text{mass} \times \text{acceleration}$$

or, $F = ma$

When a body is moving with a uniform velocity along a straight line, it neither experience nor require an external force. This is because, the acceleration is due to change in the velocity of the body and the velocity remains constant because the acceleration is due to change in the velocity of the body and the velocity remains constant for a body moving with a uniform velocity along a straight line.

When a body changes its velocity or direction of its motion, its velocity changes too. It results in an acceleration which is possible only by the action of an external applied force. Hence, an accelerated motion is always due to an external force.

Application of the change in linear momentum (impluse) and second law of motion :

- Bogies of a train are provided with the buffers. These buffers avoid severe jerks during shunting of the train. Since force = change in momentum/time and the time of impact increases due to presence of buffers. Hence, force during jerks decrease. It results in decrease in the chances of damage.
- Crockery items are wrapped in paper or straw pieces before packing because paper or straw acts as buffers. It changes the time of impact and hence, avoids the chances of damage during the jerks.
- An athlete should stop slowly, after finishing a fast race, so that the time of impact of his run increases at stop and hence, force experienced by him decreases.
- In cricket, a player lowers his hands while catching a cricket ball to avoid injury. In doing so, he increases the time of impact of the ball which in turn reduces the effect of the force on his hands.
- Shockers in the motor-vehicles reduce the effect of jerk/force by increasing the time of impact of the jerks given by an uneven road.
- In a head-on collision between two vehicles, change in linear momentum is equal to the sum of the linear momenta of the two vehicles. Since time impact is very small, hence an extra large force develops which results in maximum damage to the vehicles.
- When a person falls from a height on a concrete floor, the floor does not yield. The total change in linear-momentum is produced in a very small interval of time. Hene, the floor exerts a much larger force and the person receives more injury. But when a person falls on a heap of sand, the sand yields. The same change in linear momentum is produced in a much longer time. The average force exerted on the person by the heap of sand is, therefore, much smaller and hence the person is not hurt.

Third Law of Motion

''To every action, there is always, an equal and opposite reaction.''

Here, the action is the force exerted by one body on the other body while the reaction is the force exerted by the second body on the first.

Significance of Third Law

It signifies that forces in nature are always in pairs. A single isolated force is not possible. Force of action and reaction act always on different bodies.

They never cancel each other and each force produces its own effect. The forces of action and reaction may be due to actual physical contact of the two bodies or even from a distance. But they are always equal and opposite. This third law of motion is applicable whether the bodies are at rest or they are in motion. This law is applied to all types of forces e.g. gravitational, electric or magnetic forces, etc.

Example and application of the third law of motion

- A book placed on a table exerts a force as an action on the table. This action is equal to the weight of the book. The table exerts a force of reaction equal and opposite to the reaction to support the book.
- When a gun fires a bullet, it moves forward due to a force exerted by the gun. The bullet exerts a reaction due to which the gun recoils backward.
- We can walk on a ground easily if it is tough because the ground provides sufficient reaction against our push. But it is difficult to walk on sand or ice. This is because on pushing, sand gets displaced and reaction from sandy ground is very little. In case of ice, force of reaction is again small, because friction between our feet and ice is very little.
- When a rubber ball is struck against a wall or floor, it exerts a force as an action on the wall. The ball rebounds with an equal and opposite force as reaction exerted by the wall on the ball.
- A swimmer pushes the water with a force of action in backward direction while water pushes the swimmer with a force of reaction in the forward direction. Consequently, the swimmer is able to swim.
- When a jet-plane or rocket moves in the sky, the gases produced due to combustion of fuel escape through the nozzle in the backward direction due to the force of action exerted by the engine. The escaping gases exert a force of reaction on the jet-plane or rocket in the forward direction. Consequently, the jet-plane or rocket moves.

Principle of Conservation of Linear Momentum

The total sum of the linear momentum of all bodies in a system remains constant and is not affected due to their mutual action and reaction. It means in a system of the two bodies, the total momentum of the bodies before impact is equal to the total momentum of the two bodies after impact. The law of conservation of linear momentum is universal i.e. it applies to both, the microscopic as well as macroscopic system.

Some common applications of the principle of conservation of linear momentum:

- When a person is lying on a frictionless surface at rest, his momentum is zero. As soon as he blows air out of his mouth or throws an object, he moves in the opposite direction. The total sum of momentum of the person and air blown or object thrown remains zero due to opposite directions.
- When a man jumps out of a boat to the shore, the boat is pushed slightly away from the shore. The initial momentum of the man and boat remains equal to that of the final value.
- The gun must be held tightly to the shoulder when the gun is fired. It would save hurting the shoulder
- Motion of rocket and jet planes is based on the conservation of linear momentum. Out of the three laws of motions, the second law is the real law because it includes remaining both the first law and the third law.

Uniform Circular Motion

When a body moves along a circular path or a curve with a uniform circular speed, the body is acted upon by an inward acceleration. This acceleration acts towards the centre of a circular path or curve and is called as radial or centripetal acceleration which gives rise to the centripetal force. The centripetal force is an essential condition of the circular motion. Centripetal force (F_c) = mass of the body (m) × centripetal acceleration (a_c)

or $$F_c = ma_c$$

Centripetal acceleration

$$a_c = \frac{v^2}{r} = rw^2$$

where v = linear speed, w = angular speed or, r = radius of circular path or curve.

$$\therefore \quad F_c = ma_c = \frac{mv^2}{r} = mvw = mrw^2$$

The centripetal force acting on a body is an action and an equal and opposite force called centrifugal force appears as a reaction.

Application of centripetal force

- When a bucket containing water is whirled in a horizontal or vertical direction water does not fall down on the ground.
- In a circus, a motor cyclist is able to perform the feat of driving the motor cycle along a vertical circle in a cage. The motor cyclist does not fall down even at the highest point.
- A pilot of an aircraft can successfully loop a vertical loop without falling at the top of the loop being without belt.
- Motion of vehicles on a curved road :
  (a) **Level Curved Road :** A level curved road is constructed where the speed of the vehicles is slow. Here, the force of friction between the road and tyre of the wheel of the vehicle provides the necessary centripetal force.
  (b) **Banking of Roads :** At the highways where vehicles run fast, the frictional force is not a reliable source for providing the required centripetal force to the vehicle. Hence, at such curved roads, a safer course of action is to raise the outer edge of the curved road above the inner edge. It is known as banking of roads. The banking of roads provides the required centripetal force.
- A cyclist leans forward while going along a curve. By doing so, the ground provides him the centripetal force which he requires for turning. Hence, the cyclist leans inwards from his vertical position.
- In an atom, the required centripetal force for an electron in its circular orbit is provided by the electrostatic force of attraction between the electron and nucleus.
- The force of gravitation provides the essential centripetal force when a satellite revolves around a planet or a planet revolves around the sun.

Rotational Motion

Torque (Moment of Force)

The product of force acting on a body and perpendicular distance of line of action of the force from the axis of rotation is called moment of force or torque.

Torque = Force × Perpendicular distance from axis rotation

Applications of Torque

- Torque due to a force is maximum, the distance from the axis of rotation is maximum. We can open or close a door easily by applying force near the edge of the door i.e. at maximum distance from the hinges.
- Hence, a handle or knob is fitted near the free edge of the plank of the door. A wrench with a long arm is required to unscrew a nut fitted tightly to a bolt. Longer the arm of the wrench, smaller is the required force to give sufficient turning effect.

Angular Momentum

It is equal to the product of linear momentum of a body and the perpendicular distance from the axis of rotation. It follows the principle of conservation. It means the total angular moment of an isolated system remains always constant.

Applications of conservation of Angular Momentum:

(i) The angular velocity of revolution of a planet around the sun in an elliptical orbit increases, when the planet comes closer to the sun and vice-versa.

(ii) A circus acrobat performs feats involving spin by bringing his arms and legs closer to his body and viceversa. It is because in doing so the angular speed increases.

(iii) Consider a ballet dancer is rotating with her arms and legs stretched outwards. When she folds her arms and brings the stretched legs close to the other leg, her angular speed increases.

(iv) Due to the same reason, the angular speed of the inner layer of the tornado (whirlwind) is extremely high.

(v) All helicopters are provided with two propellers. If there was one single propeller, the helicopter would rotate itself in an opposite direction in accordance with the laws of conservation of angular momentum.

Friction

When a body moves (slides or rolls) or even tries to move over the surface of another body a tangential force comes into action between their surfaces in contact, against their relative motion. This opposing force is termed as the force of friction.

The force of friction depends upon the mass of the body on a surface and roughness of the surfaces in contact between them and the magnitude of friction, which increases with increase in roughness and mass.

When a body is at rest on a surface, the friction is called static friction which is a self adjusting force. When the body is on the verge to move (slide or roll), the friction is called limiting friction but when the body moves, it gives rise to dynamic friction.

The limitting friction is the maximum force of friction and it is always more than static or dynamic friction.

Usually, smoothness decreases the force of friction. However, when the surfaces in contact are made too smooth by polishing, the binding force of adhesion increases and hence, the frictional force increases. This is called 'cold welding'.

Friction is a non-conservative force and hence, the mechanical energy (potential and kinetic energy) is not conserved. In fact, friction converts mechanical energy partly into heat, light (spark), sound, electricity, etc.

Generally, friction opposes motion. However, in certain cases friction is essential for motion. Without friction, motion cannot be started, stopped or transferred from one body to the other. Thus, friction is a necessary evil.

Advantages of Friction

- When a person pushes the ground backward, the rough surface of the ground exerts a forward force due to friction. It makes possible a person to move on the ground. Due to lack of sufficient friction on ice or wet soil, it is difficult to walk.
- Two bodies stick together due to friction.
- The working of the brakes of vehicles is possible due to friction only.
- The friction between the tyres of vehicles and road makes the motion of the vehicles possible.
- The cleaning action of sand-paper occurs due to friction only.
- In absence of friction, we would not be able to hold a pen and if we could, the pen would not write on paper.
- Writing on the black board with a chalk is possible due to friction.
- The transfer of motion from one part of a machine to the other part through belts is possible by friction.
- The working of nuts and bolts for holding parts of machinery together is based on friction.
- The knots in woven clothes are possible due to friction.

Disadvantages of Friction

- Since, the force of friction opposes the relative motion between any two bodies in contact, hence, extra work is done to overcome the force of friction. It involves extra loss of energy. About 20% of the petrol used in an automobile is used up to overcome the force of friction in the engine and in driving.
- The force of friction results in heating the working parts of the machinery that may damage the parts.
- Friction causes wear and tear of the parts of the machinery.

The force of friction can be reduced :

- By polishing : polishing causes smoothness.
- By lubricating : The lubricants, oils, grease etc. fill up the irregularities of the surfaces and hence, the surfaces become smoother.
- By using ball-bearings

The force of friction can be increased :

- by applying sand on the slippery ground.
- by applying sand on the road covered with snow.
- by making depressions, projections, etc. in the tyres during manufacturing.

Order of the magnitude of the force of friction

Rolling friction < sliding friction < limiting friction. Owing to least value of rolling friction wheels are used in vehicles.

Miscellaneous

- When a particle goes from one point to another, the actual length of the path is called distance covered. The average speed is defined as the distance covered per unit time. In the above case, the straight line distance between the initial and final positions is called magnitude of displacement. The average velocity is defined as magnitude of displacement per unit time.
- Distance covered is always a + VE quantity. And it never decreases with time. For a moving particle it cannot be zero.
- Distance covered ≥ magnitude of displacement.

- Speed is always a + VE quantity. However, it can increase or decrease with time.
- When a particle returns to the starting point its average velocity is zero but average speed is not zero.
- For uniform motion distance covered = magnitude of displacement. The motion is along a straight line and its direction cannot change.
- If a body covers first half distance with speed v_1, and the second half distance with speed v_2, then

  average speed $\frac{2v_1v_2}{v_1+v_2}$ = Harmonic mean.

WORK, ENERGY & POWER

Work

When a force is applied on a body and a displacement is carried out in any direction except in a direction perpendicular to the direction of the force, an amount of work is done by the force.

The amount of work done is equal to the product of the force and the distance travelled in the direction of the applied force i.e.

$$\text{Work} = \text{Force} \times \text{distance travelled}$$

or, $$W = F \times S$$

Unit of work is Joule 1 joule = 1 Newton × 1 metre.

Work done by a force may be zero, positive or negative depending upon the direction of the applied force and displacement.

Do You Know?

When a coolie is carrying some load on his head and is waiting for the arrival of the train, he is not doing any work. No mechanical work is done by a teacher teaching a class. When a body falls freely under the action of gravity, work done by gravity on the body is positive. When a body is pushed or pulled by a force, work done is positive. The force of friction acts against the motion, hence the work done by the frictional force is negative.

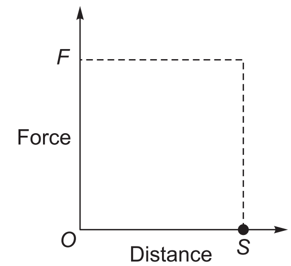
Power

The time rate of change of work is power. When a body takes less time to do a certain work, its power is said to be more and vice-versa.

$$\text{Power} = \frac{\text{work}}{\text{time}}$$

or, $$P = \frac{W}{t}$$

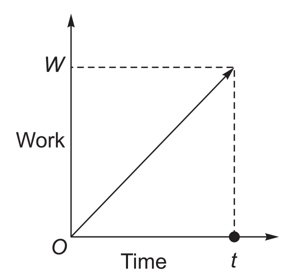
Its unit is watt (w). One kilowatt (1 kw) is equal to 1000 watt. One horse power (h.p.) is equal to 746 watt. Power of an agent measures how fast it can do the work. The area under the force versus distance graph is numerically equal to the work done by the agent.



$$\text{Work} = \text{Force} \times \text{Distance}$$

$$W = F \times S$$

The area under power-time graph gives the work done while the slope of work versus time graph gives the power.



Work = power × time

= area under W-t graph

or, $$W = Pt$$

$$\text{Power} = \text{Work/Time}$$

or, $P = w/t$ = slope of W-t graph

Energy

The ability of a body to do work is called energy. When a body can do more work, it is said to have more energy and vice versa. Energy is different from power. Energy refers to the total amount of work a body can do and power determines the rate of doing work. Both the energy of a body and work done by the body are equivalent and are measured in Joule (J).

Kinetic Energy (K.E.)

It is the energy possessed by the body by virtue of its motion. The kinetic energy of a body is given as

$$\text{K.E.} = \frac{1}{2}mv^2$$

Where m = mass of the body and v = velocity of the body. Thus, K.E. of a body is equal to half the product of mass of the body and square of velocity of the body. The change in K.E. of a body measures the work done by the body.

Work = change in K.E. of the body

or, $$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

Where u and v are initial and final velocities of the body of mass m.

When a heavy and a tight body are moving with same K.E. and same retarding force is applied on each, both the bodies will stop after travelling the same distance.

K.E. of a body is also given as :

$$\text{K.E.} = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

or, $$\text{K.E.} = \frac{P^2}{2m}$$

Hence, when a light and a heavy body are moving with the same linear momentum, the light body will have more K.E.

> Every moving system is associated with a definite amount of K.E. e.g. a moving vehicle, wind, water flow, etc.

Potential Energy (P.E.)

The energy possessed by a body by virtue of its position or configuration is known as its potential energy. The mechanical P.E. is of two types viz., gravitational P.E. and elastic P.E. The gravitational P.E. of a body at a certain height is due to gravity whereas the elastic P.E. is due to its property of elasticity.

Gravitation P.E. = mass × acceleration due to gravity × height = mgh

At the surface of the earth, $h = 0$, $\therefore$ P.E. = 0

Different Forms of Energy

1. **Heat :** It is the energy possessed by a body by virtue of random motion of the molecules or particles of the body.
2. **Internal Energy :** It is the energy of a body due to the molecular configuration and molecular motion.
3. **Electrical Energy :** This energy arises due to work done in moving free charge carriers in a particular direction through a conductor.
4. **Chemical Energy :** It is the energy possessed by the body by virtue of chemical bonding of its atoms.
5. **Nuclear Energy :** It is the energy released during the nuclear reaction due to conversion of mass into energy.

Mass-Energy Equivalence

Mass and energy are equivalent to each other and can be interconverted according to Einstein's equation $E = mc^2$ or $m = E/c^2$.

Where, E = energy, m = mass and, c = speed of light in vacuum = 3×10^8 m/s.

If mass = 1 kg, the energy released is

$$E = 1\text{ kg} \times (3 \times 10^8)^2\text{ m/s}^2 = 9 \times 10^{16}\text{ Joule}$$

This law unifies the two laws viz the law of conservation of mass and the law of conservation of energy. Most of the energy in the universe i.e. energy in stars is obtained due to conversion of mass into energy.

Principle of Conservation of Energy

The total sum of all kinds of energy of an isolated system remains constant at all times. Energy neither can be created nor be destroyed but can be transformed from one form to another. The amount of energy appearing in one form is exactly equal to the energy disappearing in some other form always.

When a body is at rest at a certain height above the surface of the earth, it only has an amount of potential energy. As soon as the body is released from that height, its P.E. begins to decrease and this decrease in P.E. appears as an increase in its K.E. When the body arives at the ground, its P.E. becomes zero and this appears as K.E.

Sources of Energy

The sources of energy are immense and they are divided into two groups viz.

- **Renewable Source :** These sources of energy are inexhaustible and are being continuously supplied by nature e.g. wind, flowing water, the sun, ocean tides, biogas, plants and vegetable waste, etc.
- **Non-renewable Source :** They are exhaustible and have been formed in nature long ago e.g. coal, petroleum, natural gas, fissionable materials like uranium.

Machine

Machine is a device to overcome load or resistance applied to it at some point by a relatively small effort applied to it at some convenient point.

Lifting machine

Lifting machine is a device to lift heavy load by applying comparatively smaller force like lever, wheel and axle, inclined plane, etc.

- **Effort :** The force applied to a machine to overcome load (resistance) is called effort.
- **Load :** The resistance (force) to be overcome by a machine is called load.

Mechanical Advatnage (M.A.): $\dfrac{\text{Load}}{\text{Effort}}$

Velocity Ratio (V.R) or Ideal Mechanical Advantage (IMA)

$$= \frac{\text{Displacment of effort}}{\text{Displacement of load in the sametime}}$$

Efficiency of a machine

$$= \frac{\text{Useful work}}{\text{Total work done}}$$

$$= \frac{\text{Mechanical Advantage (M.A.)}}{\text{Velocity Ratio (V.R.)}}$$

Efficiency is always less than one or less than 100%. Ony for ideal machines, the efficiency is one or 100%. V.R. or I.M.A. for some simple machines:

(i) Lever : I.M.A. = $\dfrac{\text{Effort arm}}{\text{Load arm}}$

(ii) Whel nd Ale :

$$\text{I.M.A.} = \frac{\text{Radius of Wheel}}{\text{Radius of axle}}$$

PRESSURE

Pressure

Pressure is defined as force acting normally on unit area of the surface. SI unit of pressure is N/m^2 also called Pascal (*Pa*). Pressure is an scalar quantity.

$$\text{Pressure } (P) = \frac{F}{A} = \frac{\text{Normal force acting on the surface}}{\text{Area of the surface}}$$

Atmospheric Pressure

Atmospheric pressure is that pressure which is exerted by the atmospheric gases and measured by a mercury column of 76 cm length at 0°C at 45° latitude at the sea-level. It is equal to weight of 76 cm column of mercury of cross-section area 1 cm^2. Generally, it is measured in bar.

Atmospheric pressure 1atm = 1.01bar=1.01×10^5 N/m^2

Do You Know?

- It is difficult to cook on the mountain as the pressure is low on mountain in comparison to plain areas as atmospheric pressure decreases with the increase of height.
- The fountain pen of a passenger leaks in aeroplane at height, due to reduction in atmospheric pressure.

Measurement of Pressure

- Barometer measures the atmospheric pressure.
- Sudden fall in barometric reading is the indication of storm.
- Slow fall in barometric reading is the indication of rain.
- Slow rise in the barometric reading is the indication of clear weather.

Pascal's Law of Pressure

It states that "the pressure exerted anywhere at a point of confined fluid is transmitted equally in all directions throughout the liquid". Examples: Hydraulic lift, hydraulic press, hydraulic brake, etc. work on the Pascal's law.

Effects:

- If gravitational attraction is negligible in equilibrium condition, pressure is same at all points in a liquid.
- If an external pressure is applied to an enclosed fluid, it is transmitted undiminished to every direction.

Effect of pressure on Melting Point and Boiling Point

(i) The melting point of substances which expands on fusion increases with the increase in pressure. **Example:** Wax.

(ii) The melting point of substances which contracts on fusion decreases with the increase in pressure. **Example:** Ice.

(iii) Boiling point of all the substances increases with the increase in pressure.

PHYSICS
Practice Questions

Q.1 A liquid is kept in a regular cylindrical vessel up to a certain height. If this vessel is replaced by another cylindrical vessel having half the area of cross-section of the bottom, the pressure on the bottom will
(a) Remain unaffected
(b) Be reduced to half the earlier pressure
(c) Be increase to twice the earlier pressure
(d) Be reduced to one-fourth the earlier pressure

Q.2 In SONAR, we use
(a) Ultrasonic waves
(b) Infrasonic waves
(c) Radio waves
(d) Audible sound waves

Q.3 Which one of the following reactions is the main cause of the energy radiation from the Sun?
(a) Fusion reaction
(b) Fission reaction
(c) Chemical reaction
(d) Diffusion reaction

Q.4 Two identical piano wires have same fundamental frequency when kept under the same tension. What will happen if tension of one of the wire is slightly increased and both the wire are made to vibrate simultaneously?
(a) Noise (b) Beats
(c) Resonance (d) Non-linear effects

Q.5 Which one among the following correctly defines a unit magnetic pole in SI units?
It is the pole which when placed in air at a distance of
(a) 1 foot from an equal and a similar pole repels it with a force of 1 pound
(b) 1 metre from an equal and similar pole repels it with a force of 1 newton
(c) 1 cm from an equal and a similar pole repels it with a force of 1 dyne
(d) 1 metre from an equal and a similar pole repels it with a force of 1 newton/m^2

Q.6 Which one of the following phenomena is associated with the fire flies giving cold light in night?
(a) Fluorescence
(b) Phosphorescence
(c) Chemiluminescence
(d) Effervescence

Q.7 When a ball drops onto the floor it bounces back. Why does it bounce?
(a) The floor is perfectly fluid
(b) The floor heats up on impact
(c) Newton's third law implies that for every action (drop), there is a reaction (bounce)
(d) The floor exerts a force on the ball during the impact

Q.8 When you pull out the plug connected to an electric appliance, you will often observe a spark. To which property of the appliance is this related?
(a) Resistance (b) Inductance
(c) Capacitance (d) Wattage

Q.9 In scuba diving, while ascending towards the water surface, there is a danger of bursting the lungs. It is because
(a) Graham's law of diffusion
(b) Archimedes' principle
(c) Boyle's law
(d) Henry's law

Q.10 The most familiar form of radiant energy in sunlight that cause tanning and has the potential for casing melanoma in humans is called
(a) Infra-red radiation
(b) Visible radiation
(c) Ultra-violet radiation
(d) Microwave radiation

Q.11 An athlete diving off high springboard can perform a variety of exercise in the air before entering the water body. Which one of the following parameters will remain constant during the fall?
(a) The athlete's linear momentum
(b) The athlete's angular momentum
(c) The athlete's kinetic energy
(d) The athlete's moment of inertia

Q.12 Why are the inner lining of hot water made up of copper?
(a) Copper has less heat capacity
(b) Copper has high electrical conductivity
(c) Copper does not react with steam
(d) Copper is good conductor of both heat and electricity

Q.13 Hair of a shaving brush cling together when the brush is removed from water due to
(a) viscosity (b) elasticity
(c) friction (d) surface tension

Q.14 Which one of the following forces lead to separation of the cream from the churned milk?
(a) Gravitational force
(b) Cohesive force
(c) Centripetal force
(d) Centrifugal force

Q.15 By which one of the following, an old written material which cannot be read easily can be read?
(a) Alpha-rays (b) Beta-rays
(c) X-rays (d) IR-rays

Q.16 Which one of the following common devices works on the basis of the principle of mutual induction?
(a) Tube light (b) Transformer
(c) LED (d) Photodiode

Q.17 'Mirage' is a phenomenon due to
(a) Reflection of light
(b) Refraction of light
(c) Total internal reflection of light
(d) Total diffraction of light

Q.18 Who had showed that the electric and magnetic waves are equal to vacuum?
(a) Isaac Newton
(b) James Clerk Maxwell
(c) Albert Einstein
(d) Werner Heisenberg

Q.19 Neutron was discovered by
(a) Rutherford
(b) Chadwick
(c) Hahn and Strassman
(d) Millikan

Q.20 Which of the following has the most penetrating power?
(a) Alpha-particles
(b) Beta-particles
(c) Gamma-particles
(d) X-rays

Q.21 The blackboard seems black because it
(a) reflects every colour.
(b) does not reflect any colour.
(c) absorbs black colour.
(d) reflects black colour.

Q.22 The solar system is an example of
(a) conservation of energy.
(b) conservation of linear momentum.
(c) conservation of angular momentum.
(d) None of the above

Q.23 If the spinning speed of the earth is increased then the weight of body at the equator
(a) increases (b) decreases
(c) doubles (d) does not change

Q.24 Cryogenic engine finds application in
(a) washing machine
(b) frost free refrigerator
(c) rocket technology
(d) sub-marine propulsion

Q.25 A solid sphere, disc and solid cylinder all of same mass and made of same material are allowed to roll down (from rest) on incline plane then
(a) disc will reach the bottom first
(b) solid sphere will reach the bottom first
(c) solid cylinder will reach the bottom first
(d) All of them will reach the bottom at the same time

Q.26 Which one of the following planets is said to be 'Twin sister' of the Earth?
(a) Mercury
(b) Venus
(c) Mars
(d) Jupiter

Q.27 The melodious effect on our ear produces by the combination of two or more notes of the modern pop songs is called
(a) concord (b) chords
(c) beats (d) overtones

Q.28 Which one of the following is responsible for the energy release by stars?
(a) Fission
(b) Fusion
(c) Chemical reaction
(d) Gravitational collapse

Q.97 What Is the wavelength of visible spectrum ?
(a) 1300A°-3000A°
(b) 3900 A° - 7600 A°
(c) 7800 A° - 8000 A°
(d) 8500 A° - 9800 A°

Q.98 The sky appears blue because of
(a) Atmospheric water vapour
(b) Scattering of light
(c) Reflection on sea water
(d) Emission of blue wavelength by the sun

Q.99 Oil rises up the wick in a lamp because
(a) Oil is very light
(b) Of the diffusion of oil through the wick
(c) Of the surface tension phenomenon
(d) Of the capillary action phenomenon

Q.100 The hydraulic brakes used in automobiles is a direct application of:
(a) Archimedes principle
(b) Toricellian law
(c) Bernoulli's theorem
(d) Pascal's law

Q.101 For a body moving with non-uniform velocity and uniform acceleration
(a) Displacement - Time graph is linear
(b) Displacement - Time graph is non-linear
(c) Velocity - Time graph is nonlinear
(d) Velocity - Time graph is linear

Q.102 Lamberts law is related to
(a) Reflection (b) Refraction
(c) Interference (d) Illumination

103. Decibel is the unit used for
(a) Speed of light
(b) Intensity of heat
(c) Intensity of sound
(d) Radio wave frequency

104. The atmospheric layer reflecting 'radio waves is called
(a) Ozonosphere (b) Ionosphere
(c) Stratosphere (d) Mesosphere

105. The mass-energy relation is the outcome of
(a) quantum theory
(b) general theory of relativity
(c) field theory of energy
(d) special theory of relativity

106. Danger signals are generally red as red light
(a) is least bright
(b) undergoes least deviation
(c) has lowest velocity
(d) gives comfort to eye

107. Heat from the sun reaches earth by the process of
(a) Conduction (b) Convection
(c) Radiation (d) All of the above

108. The instrument for measuring intensity of earthquakes is called
(a) Ediograph
(b) Pantagraph
(c) Ergograph
(d) Seismograph

Answer Key

General Science | Chapter 1 • Physics

1. (c)	2. (a)	3. (a)	4. (b)	5. (b)	6. (c)	7. (d)	8. (a)	9. (c)
10. (c)	11. (b)	12. (d)	13. (d)	14. (d)	15. (d)	16. (b)	17. (c)	18. (b)
19. (b)	20. (c)	21. (b)	22. (c)	23. (b)	24. (c)	25. (b)	26. (b)	27. (a)
28. (b)	29. (d)	30. (b)	31. (a)	32. (a)	33. (a)	34. (b)	35. (a)	36. (a)
37. (c)	38. (b)	39. (c)	40. (c)	41. (b)	42. (a)	43. (b)	44. (d)	45. (c)
46. (b)	47. (c)	48. (c)	49. (c)	50. (d)	51. (b)	52. (d)	53. (c)	54. (a)
55. (c)	56. (b)	57. (b)	58. (d)	59. (a)	60. (b)	61. (b)	62. (a)	63. (d)
64. (c)	65. (c)	66. (d)	67. (a)	68. (c)	69. (d)	70. (a)	71. (b)	72. (b)
73. (d)	74. (a)	75. (b)	76. (c)	77. (a)	78. (b)	79. (b)	80. (d)	81. (a)
82. (c)	83. (c)	84. (a)	85. (b)	86. (b)	87. (c)	88. (b)	89. (c)	90. (b)
91. (c)	92. (c)	93. (b)	94. (b)	95. (c)	96. (a)	97. (b)	98. (b)	99. (d)
100. (d)	101. (b)	102. (d)	103. (c)	104. (b)	105. (d)	106. (b)	107. (c)	108. (d)