

School Arithmetic through Physics and Chemistry

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Abstract—This book provides applications of arithmetic using problems from Physics and Chemistry from class 9-12. Links to sample Python codes are available in the text.

Download python codes using

svn co <https://github.com/gadepall/school/trunk/ncert/arithmetic/codes>

1 EXAMPLES

1. An object travels 16m in 4s and then another 16 m in 2 s. What is the average speed of the object?
2. The odometer of a car reads 2000 km at the start of a tri and 2400 km at the end of the trip. If the trip took 8 h, calculat the average speed of the car in km/h and m/s.
3. Usha swims in a 90m long pool. She covers 180m in one minute by swimming from one end to the other and back along the same straight path. Find the average speed and average velocity of Usha.
4. Starting from a stationary position, Rahul paddles his bicycle to attain a velocity of $6ms^{-1}$ in 30s. Then he applies brakes such that the velocity of the bicycle comes down to $4ms^{-1}$ the next 5s. Calculate the acceleration of the bicycle in both the cases
5. A train starting from rest attains a velocity of $72kmh^{-1}$ in 5 minutes. Assuming that the

acceleration is uniform, find (i) the acceleration and (ii) the distance travelled by the train for attaining this velocity.

6. A car accelerates uniformly from $18kmh^{-1}$ to $36kmh^{-1}$ in 5s. Calculate
 - a) the acceleration and
 - b) the distance covered by the car in that time.
7. The brakes applied to a car produce an acceleration of $6ms^{-2}$ in the opposite direction to the motion. If the car takes 2s to stop after the application of brakes, calculate the distance it travels during this time.
8. A constant force acts on an object of mass 5 kg for a duration of 2 s. It increases the object's velocity from $3 ms^{-1}$ to $7 ms^{-1}$. Find the magnitude of the applied force. Now, if the force was applied for a duration of 5 s, what would be the final velocity of the object?
9. Which would require a greater force – accelerating a 2 kg mass at $5 ms^{-2}$ or a 4 kg mass at $2 ms^{-2}$?
10. A motorcar is moving with a velocity of 108 km/h and it takes 4 s to stop after the brakes are applied. Calculate the force exerted by the brakes on the motorcar if its mass along with the passengers is 1000 kg.
11. A force of 5 N gives a mass m_1 , an acceleration of $10 ms^{-2}$ mass m_2 , an acceleration of $20 ms^{-2}$ and a . What acceleration would it give if both the masses were tied together?
12. A bullet of mass 20 g is horizontally fired with a velocity $150 ms^{-1}$ What is the recoil velocity of the pistol?
13. A girl of mass 40 kg jumps with a horizontal velocity of $5 ms^{-1}$ onto a stationary cart with frictionless wheels. The mass of the cart is 3 kg. What is her velocity as the cart starts moving? Assume that there is no external unbalanced force working in the horizontal

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direction.

14. Two hockey players of opposite teams, while trying to hit a hockey ball on the ground collide and immediately become entangled. One has a mass of 60 kg and was moving with a velocity 5.0 ms^{-1} while the other has a mass of 55 kg and was moving faster with a velocity 6.0 ms^{-1} towards the first player. In which direction and with what velocity will they move after they become entangled? Assume that the frictional force acting between the feet of the two players and ground is negligible.
15. The mass of the earth is $6 \times 10^{24} \text{ kg}$. If the distance between the earth and the moon is $3.84 \times 10^5 \text{ m}$. Calculate the force exerted by the earth on the moon. (Take $G = 6.7 \times 10^{-11} \text{ Nm}^2$)
16. A car falls off a ledge and drops to the ground in 0.5 s.
 - a) What is its speed on striking the ground?
 - b) What is its average speed during the 0.5 s?
 - c) How high is the ledge from the ground?
 Let $g = 10 \text{ ms}^{-2}$.
17. An object is thrown vertically upwards and rises to a height of 10 m. Calculate (i) the velocity with which the object was thrown upwards and (ii) the time taken by the object to reach the highest point. Let $g = 9.8 \text{ ms}^{-2}$.
18. Mass of an object is 10 kg. What is its weight on the earth?
19. An object weighs 10 N when measured on the surface of the earth. What would be its weight when measured on the surface of the moon?
20. A block of wood is kept on a tabletop. The mass of wooden block is 5 kg and its dimensions are $40 \text{ cm} \times 20 \text{ cm} \times 10 \text{ cm}$. Find the pressure exerted by the wooden block on the table top if it is made to lie on the table top with its sides of dimensions (a) $20 \text{ cm} \times 10 \text{ cm}$ and (b) $40 \text{ cm} \times 20 \text{ cm}$.
21. Relative density of silver is 10.8. The density of water is 103 kgm^{-3} . What is the density of silver in SI unit?
22. A force of 7 N acts on an object. The displacement is, say 8 m, in the direction of the force. Let us take it that the force acts on the object through the displacement. What is the work done in this case?
23. A porter lifts a luggage of 15 kg from the ground and puts it on his head 1.5 m above the ground. Calculate the work done by him on the luggage.
24. An object of mass 15 kg is moving with a uniform velocity of 4 ms^{-1} . What is the kinetic energy possessed by the object?
25. What is the work to be done to increase the velocity of a car from 30 kmh^{-1} to 60 kmh^{-1} the car is 1500 kg?
26. The kinetic energy of an object of mass, m moving with a velocity of 5 ms^{-1} is 25 J. What will be its kinetic energy when its velocity is doubled? What will be its kinetic energy when its velocity is increased three times?
27. Find the energy possessed by an object of mass 10 kg when it is at a height of 6 m above the ground. Given, $g = 9.8 \text{ ms}^{-2}$.
28. An object of mass 12 kg is at a certain height above the ground. If the potential energy of the object is 480 J, find the height at which the object is with respect to the ground. Given, $g = 10 \text{ ms}^{-2}$.
29. Two girls, each of weight 400 N climb up a rope through a height of 8 m. We name one of the girls A and the other B. Girl A takes 20 s while B takes 50 s to accomplish this task. What is the power expended by each girl?
30. A boy of mass 50 kg runs up a staircase of 45 steps in 9 s. If the height of each step is 15 cm, find his power. Take $g = 10 \text{ ms}^{-2}$.
31. An electric bulb of 60 W is used for 6 h per day. Calculate the 'units' of energy consumed in one day by the bulb.
32. A sound wave has a frequency of 2 kHz and wave length 35 cm. How long will it take to travel 1.5 km?
33. A person clapped his hands near a cliff and heard the echo after 2 s. What is the distance of the cliff from the person if the speed of the sound, v is taken as 346 ms^{-1} ?
34. A ship sends out ultrasound that returns from the seabed and is detected after 3.42 s. If the speed of ultrasound through seawater is 1531 m/s, what is the distance of the seabed from the ship?
35. A convex mirror used for rear-view on an automobile has a radius of curvature of 3.00 m. If a bus is located at 5.00 m from this mirror, find the position, nature and size of the image.
36. An object, 4.0 cm in size, is placed at 25.0 cm

in front of a concave mirror of focal length 15.0 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Find the nature and the size of the image.

37. A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens? Also, find the magnification produced by the lens.
38. A 2.0 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 10 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. Also find its magnification.
39. A current of 0.5 A is drawn by a filament of an electric bulb for 10 minutes. Find the amount of electric charge that flows through the circuit.
40. How much work is done in moving a charge of 2 C across two points having a potential difference 12 V?
41. a) How much current will an electric bulb draw from a 220 V source, if the resistance of the bulb filament is 1200 Ω ?
b) How much current will an electric heater coil draw from a 220 V source, if the resistance of the heater coil is 100 Ω ?
42. The potential difference between the terminals of an electric heater is 60 V when it draws a current of 4 A from the source. What current will the heater draw if the potential difference is increased to 120 V?
43. Resistance of a metal wire of length 1 m is 26 Ω at 20°C. If the diameter of the wire is 0.3 mm, what will be the resistivity of the metal at that temperature? Predict the material of the wire.
44. A wire of given material having length l and area of cross-section A has a resistance of 4 Ω . What would be the resistance of another wire of the same material having length $l/2$ and area of cross-section $2A$?
45. An electric lamp, whose resistance is 20 Ω , and a conductor of 4 Ω resistance are connected in series to a 6 V battery. Calculate (a) the total resistance of the circuit, (b) the current through the circuit, and (c) the potential difference across the electric lamp and conductor.
46. Resistors R_1 , R_2 and R_3 connected in parallel, have the values 5 Ω , 10 Ω , 30 Ω , respectively,

which have been connected to a battery of 12 V. Calculate

- a) the current through each resistor,
 - b) the total current in the circuit, and
 - c) the total circuit resistance.
47. If in Fig. 1.47, $R_1 = 10 \Omega$, $R_2 = 40 \Omega$, $R_3 = 30 \Omega$, $R_4 = 20 \Omega$, $R_5 = 60 \Omega$, and a 12 V battery is connected to the arrangement. Calculate
- a) the total resistance in the circuit, and
 - b) the total current flowing in the circuit.

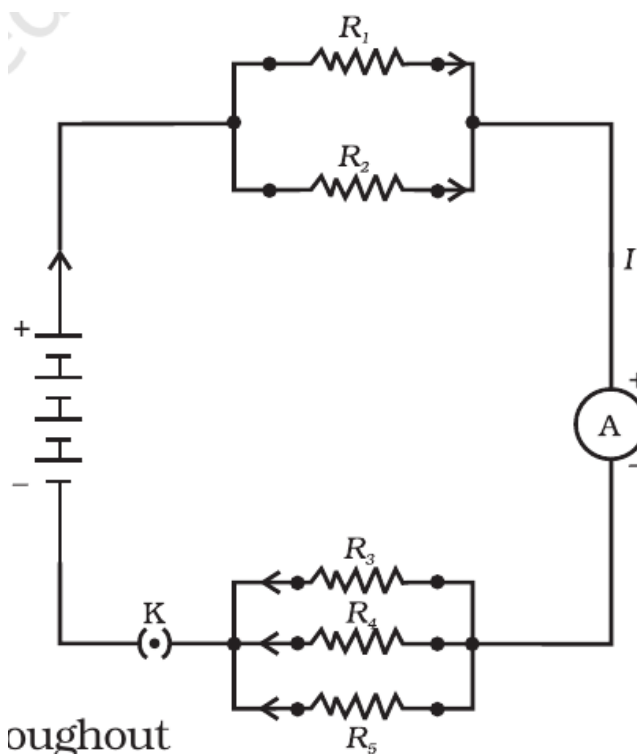


Fig. 1.47

48. An electric iron consumes energy at a rate of 840 W when heating is at the maximum rate and 360 W when the heating is at the minimum. The voltage is 220 V. What are the current and the resistance in each case?
49. 100 J of heat is produced each second in a 4 Ω resistance. Find the potential difference across the resistor.
50. An electric bulb is connected to a 220 V generator. The current is 0.50 A. What is the power of the bulb?
51. An electric refrigerator rated 400 W operates 8 hour/day. What is the cost of the energy to operate it for 30 days at Rs 3.00 per kW h?

2 EXERCISES

1. A bus starting from rest moves with a uniform acceleration of 0.1ms^{-2} for 2 minutes. Find
 - a) the speed acquired,
 - b) the distance travelled.
2. A train is travelling at a speed of 90kmh^{-1} . Brakes are applied. Find so as to produce a uniform acceleration of -0.5ms^{-2} how far the train will go before it is brought to rest.
3. A trolley, while going down an inclined plane, has an acceleration of 2cms^{-2} . What will be its velocity 3s after the start? . What
4. A racing car has a uniform acceleration of 4ms^{-2} distance will it cover in 10s after start?
5. A stone is thrown in a vertically upward direction with a velocity of 5ms^{-1} . If the acceleration of the stone during its motion is 10ms^{-2} in the downward direction, what will be the height attained by the stone and how much time will it take to reach there?
6. An athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 minutes 20 s?
7. Joseph jogs from one end A to the other end B of a straight 300 m road in 2 minutes 30 seconds and then turns around and jogs 100 m back to point C in another 1 minute. What are Joseph's average speeds and velocities in jogging
 - a) from A to B and
 - b) from A to C?
8. Abdul, while driving to school, computes the average speed for his trip to be 20kmh^{-1} . On his return trip along the same route, there is less traffic and the average speed is 30kmh^{-1} . What is the average speed for Abdul's trip?
9. A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0ms^{-2} for 8.0 s. How far does the boat travel during this time?
10. A driver of a car travelling at 52kmh^{-1} applies the brakes and in another car applies accelerates uniformly in the opposite direction. The car stops in 5 s. Another driver going at 3kmh^{-1} his brakes slowly and stops in 10 s. On the same graph paper, plot the speed versus time graphs for the two cars. Which of the two cars travelled farther after the brakes were applied?
11. A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10ms^{-2} , with what velocity will it strike the ground? After what time will it strike the ground?
12. An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 hours to revolve around the earth.
13. From a rifle of mass 4 kg, a bullet of mass 50 g is fired with an initial velocity of 35ms^{-1} . Calculate the initial recoil velocity of the rifle.
14. Two objects of masses 100 g and 200 g are moving along the same line and direction with velocities of 2ms^{-1} and 1ms^{-1} , respectively. They collide and after the collision, the first object moves at a velocity of 1.67ms^{-1} . Determine the velocity of the second object.
15. A truck starts from rest and rolls down a hill with a constant acceleration. It travels a distance of 400 m in 20 s. Find its acceleration. Find the force acting on it if its mass is 7 tonnes (Hint: 1 tonne = 1000 kg.)
16. A stone of 1 kg is thrown with a velocity of 20ms^{-1} across the frozen surface of a lake and comes to rest after travelling a distance of 50 m. What is the force of friction between the stone and the ice?
17. A 8000 kg engine pulls a train of 5 wagons, each of 2000 kg, along a horizontal track. If the engine exerts a force of 40000 N and the track offers a friction force of 5000 N, then calculate:
 - a) the net accelerating force and
 - b) the acceleration of the train.
18. An automobile vehicle has a mass of 1500 kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of 1.7ms^{-2}
19. Using a horizontal force of 200 N, we intend to move a wooden cabinet across a floor at a constant velocity. What is the friction force that will be exerted on the cabinet?
20. Two objects, each of mass 1.5 kg, are moving in the same straight line but in opposite directions. The velocity of each object is 2.5ms^{-1} before the collision during which they stick together. What will be the velocity of the combined object after collision?

21. A hockey ball of mass 200 g travelling at 10 ms^{-1} is struck by a hockey stick so as to return it along its original path with a velocity at 5 ms^{-1} momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.
22. A bullet of mass 10 g travelling horizontally with a velocity of 150 ms^{-1} strikes a stationary wooden block and comes to rest in 0.03 s. Calculate the distance of penetration of the bullet into the block. Also calculate the magnitude of the force exerted by the wooden block on the bullet.
23. An object of mass 1 kg travelling in a straight line with a velocity of 10 ms^{-1} collides with, and sticks to, a stationary wooden block of mass 5 kg. Then they both move off together in the same straight line. Calculate the total momentum just before the impact and just after the impact. Also, calculate the velocity of the combined object.
24. An object of mass 100 kg is accelerated uniformly from a velocity of 5 ms^{-1} to 8 ms^{-1} in 6 s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object.
25. How much momentum will a dumb-bell of mass 10 kg transfer to the floor if it falls from a height of 80 cm? Take its downward acceleration to be 10 ms^{-2} . Calculate the magnitude of change of
26. Two persons manage to push a motorcar of mass 1200 kg at a uniform velocity along a level road. The same motorcar can be pushed by three persons to produce an acceleration of 0.2 ms^{-2} . With what force does each person push the motorcar? (Assume that all persons push the motorcar with the same muscular effort.)
27. A hammer of mass 500 g, moving at 50 ms^{-1} , strikes a nail. The nail stops the hammer in a very short time of 0.01 s. What is the force of the nail on the hammer?
28. A motorcar of mass 1200 kg is moving along a straight line with a uniform velocity of 90 km/h. Its velocity is slowed down to 18 km/h in 4 s by an unbalanced external force. Calculate the acceleration and change in momentum. Also calculate the magnitude of the force required.
29. What is the magnitude of the gravitational force between the earth and a 1 kg object on its surface? (Mass of the earth is 6×10^{24} kg and radius of the earth is 6.4×10^6 m.)
30. A ball is thrown vertically upwards with a velocity of 49 m/s. Calculate
 - a) the maximum height to which it rises,
 - b) the total time it takes to return to the surface of the earth.
31. A stone is released from the top of a tower of height 19.6 m. Calculate its final velocity just before touching the ground.
32. A stone is thrown vertically upward with an initial velocity of 40 m/s. Taking $g = 10 \text{ ms}^{-2}$, find the maximum height reached by the stone. What is the net displacement and the total distance covered by the stone?
33. Calculate the force of gravitation between the earth and the Sun, given that the mass of the earth = 6×10^{24} kg and of the Sun = 2×10^{30} kg. The average distance between the two is 1.5×10^{11} m.
34. A stone is allowed to fall from the top of a tower 100 m high and at the same time another stone is projected vertically upwards from the ground with a velocity of 25 m/s. Calculate when and where the two stones will meet.
35. A ball thrown up vertically returns to the thrower after 6 s. Find
 - a) the velocity with which it was thrown up,
 - b) the maximum height it reaches, and
 - c) its position after 4 s.
36. The volume of 50 g of a substance is 20 cm^3 . If the density of water is 1 gcm^{-3} , will the substance float or sink?
37. The volume of a 500 g sealed packet is 350 cm^3 . Will the packet float or sink in water if the density of water is 1 gcm^{-3} ? What will be the mass of the water displaced by this packet?
38. Certain force acting on a 20 kg mass changes its velocity from 5 ms^{-1} to 2 ms^{-1} . Calculate the work done by the force.
39. A certain household has consumed 250 units of energy during a month. How much energy is this in joules?
40. An object of mass 40 kg is raised to a height of 5 m above the ground. What is its potential energy? If the object is allowed to fall, find its kinetic energy when it is half-way down.

41. An electric heater is rated 1500 W. How much energy does it use in 10 hours?
42. Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h?
43. Find the energy in kW h consumed in 10 hours by four devices of power 500 W each.
44. An echo is heard in 3 s. What is the distance of the reflecting surface from the source, given that the speed of sound is 342 ms^{-1} ?
45. A submarine emits a sonar pulse, which returns from an underwater cliff in 1.02 s. If the speed of sound in salt water is 1531 m/s, how far away is the cliff?
46. A person has a hearing range from 20 Hz to 20 kHz. What are the typical wavelengths of sound waves in air corresponding to these two frequencies? Take the speed of sound in air as 344 ms^{-1} .
47. Two children are at opposite ends of an aluminium rod. One strikes the end of the rod with a stone. Find the ratio of times taken by the sound wave in air and in aluminium to reach the second child.
48. The frequency of a source of sound is 100 Hz. How many times does it vibrate in a minute?
49. A stone is dropped from the top of a tower 500 m high into a pond of water at the base of the tower. When is the splash heard at the top? Given, $g = 10 \text{ ms}^{-2}$ and speed of sound $= 340 \text{ ms}^{-1}$.
50. A sound wave travels at a speed of 339 ms^{-1} 174 . If its wavelength is 1.5 cm, what is the frequency of the wave? Will it be audible?
51. A sonar device on a submarine sends out a signal and receives an echo 5 s later. Calculate the speed of sound in water if the distance of the object from the submarine is 3625 m.
52. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and the nature of the image formed.
53. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.
54. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.
55. The magnification produced by a plane mirror is +1. What does this mean?
56. An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size.
57. An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focussed image can be obtained? Find the size and the nature of the image.
58. Find the focal length of a lens of power - 2.0 D. What type of lens is this?
59. A doctor has prescribed a corrective lens of power +1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging?
60. Judge the equivalent resistance when the following are connected in parallel -
 - a) 1Ω and $10^6 \Omega$,
 - b) 1Ω and $10^3 \Omega$, and $10^6 \Omega$.
61. An electric lamp of 100Ω , a toaster of resistance 50Ω , and a water filter of resistance 500Ω are connected in parallel to a 220 V source. What is the resistance of an electric iron connected to the same source that takes as much current as all three appliances, and what is the current through it?
62. How can three resistors of resistances 2Ω , 3Ω , and 6Ω be connected to give a total resistance of
 - a) 4Ω ,
 - b) 1Ω ?
63. What is
 - a) the highest,
 - b) the lowest total resistance
 that can be secured by combinations of four coils of resistance 4Ω , 8Ω , 12Ω , 24Ω ?
64. A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R' , then the ratio R/R' is -
65. An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be -
66. Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then parallel in a circuit across the same potential difference.

The ratio of heat produced in series and parallel combinations would be -

67. A copper wire has diameter 0.5 mm and resistivity of $1.6 \times 10^{-8} \Omega \text{ m}$. What will be the length of this wire to make its resistance 10 Ω ? How much does the resistance change if the diameter is doubled?
68. When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.
69. A battery of 9 V is connected in series with resistors of 0.2 Ω , 0.3 Ω , 0.4 Ω , 0.5 Ω and 12 Ω , respectively. How much current would flow through the 12 Ω resistor?
70. How many 176 Ω resistors (in parallel) are required to carry 5 A on a 220 V line?
71. Show how you would connect three resistors, each of resistance 6 Ω , so that the combination has a resistance of
 - a) 9 Ω ,
 - b) 4 Ω .
72. Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A?
73. A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of 24 Ω resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?
74. Compare the power used in the 2 Ω resistor in each of the following circuits:
 - a) a 6 V battery in series with 1 Ω and 2 Ω resistors, and
 - b) a 4 V battery in parallel with 12 Ω and 2 Ω resistors.
75. Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to electric mains supply. What current is drawn from the line if the supply voltage is 220 V?
76. Which uses more energy, a 250 W TV set in 1 hr, or a 1200 W toaster in 10 minutes?
77. An electric heater of resistance 8 Ω draws 15 A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.