CBSE

WORK ENERGY AND POWER WS 4

Class 11 - Physics

Section A

1. A person trying to lose weight (dieter) lifts a 10 kg mass, one thousand times, to a height of 0.5 m each time. Assume that the potential energy lost each time she lowers the mass is dissipated. How much work does she do against the gravitational force? **[1]**

   a) 49000 J
   b) 55000 J
   c) 59000 J
   d) 45000 J

2. A spring of force constant 800 Nm^{-1} has an extension of 5 cm. The work done in extending it from 5 cm to 15 cm is **[1]**

   a) 32 J
   b) 24 J
   c) 8 J
   d) 16 J

3. A 0.800-kg ball is tied to the end of a string 1.60 m long and swung in a vertical circle. Calculate the total work done on the ball by **[1]**

   i. the tension in the string and
   ii. gravity for motion along the semicircle from the lowest to the highest point on the path.

   a) 0, -281 J
   b) 0, -251 J
   c) 0, -2.51 J
   d) 0, -25.1 J

4. **Assertion (A):** When a body moves along a circular path, no work is done by the centripetal force. **[1]**
   Reason (R): The centripetal force is used in moving the body along the circular path and hence no work is done.

   a) Both A and R are true and R is the correct explanation of A.
   b) Both A and R are true but R is not the correct explanation of A.
   c) A is true but R is false.
   d) A is false but R is true.

5. **Assertion (A):** In one-dimensional motion with constant acceleration, the power delivered is proportional to time. **[1]**
   Reason (R): In general, power is equal to the product of the force applied and its velocity.

   a) Both A and R are true and R is the correct explanation of A.
   b) Both A and R are true but R is not the correct explanation of A.
   c) A is true but R is false.
   d) A is false but R is true.

6. **Assertion (A):** When the force retards the motion of a body the work done is zero. **[1]**
   Reason (R): Work done depends on angle between force and displacement.

   a) Both A and R are true and R is the correct explanation of A.
   b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

7. **Assertion (A):** A weight lifter does no work while holding the weight up. **[1]**

Reason (R): Work is not done since the distance moved is zero.

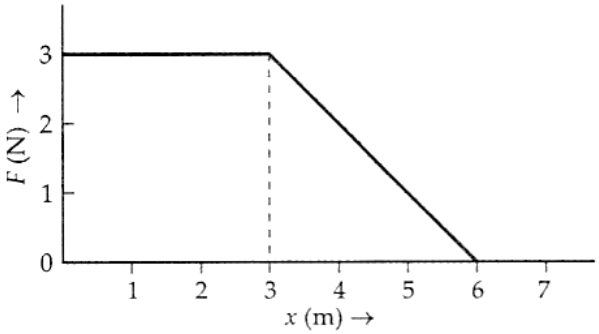
a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

8. A force F acting on an object varies with distance x as shown here. The force is in N and x in m. The work done by the force in moving the object from x = 0 to x = 6 m is **[1]**



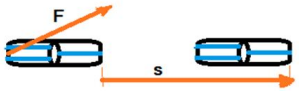
a) 4.5 J

b) 13.5 J

c) 18.0 J

d) 9.0 J

9. Balram exerts a steady force of magnitude F = $200\hat{\mathbf{i}} + 2.0\hat{j}$ on the stalled car as shown in the figure above, he pushes it a distance s = $10\hat{\mathbf{i}} + 10\hat{j}$ m. How much work does he do? **[1]**



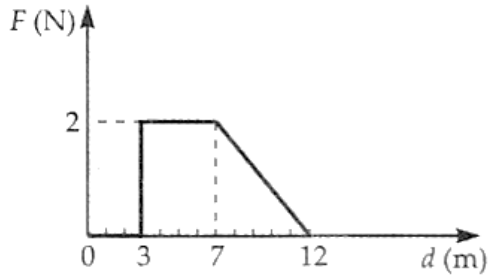
a) 2220 J

b) 2120 J

c) 2320 J

d) 2020 J

10. Force F on a particle moving in a straight line varies with distance d as shown in the figure. The work done on the particle during its displacement of 12 m is **[1]**



a) 18 J

b) 13 J

c) 26 J

d) 21 J

11. Does the work done in raising a suitcase onto a platform depend upon how fast it is raised up? **[1]**

12. What are central forces? Are they conservative in nature? **[1]**

13. A uniform chain of length L and mass M is lying on a smooth table and one-third of its length is hanging vertically down over the edge of the table. If g is the acceleration due to gravity, calculate the work required to pull the hanging part on the chain. **[1]**

14. What should be the angle between the directions of force and displacement for maximum and minimum work? **[1]**

15. Under what condition is the work done by a force is zero inspite of displacement being taking place? **[1]**

Section B

16. A particle moves along the x-axis from x = 0 to x = 5 m under the influence of a force given by $F = 7 - 2x + 3x^2$. Find the work done in the process. **[2]**

17. A cluster of clouds at a height of 1000 m above the earth burst and enough rain fell to cover an area of 10^6 m^2 with a depth of 2 cm. How much work would have been done in raising water to the height of clouds? **[2]**

Take g = 9.8 ms^{-2} and density of water =10^3 kg m^{-3}.

18. What are the conditions for work to be zero? **[2]**

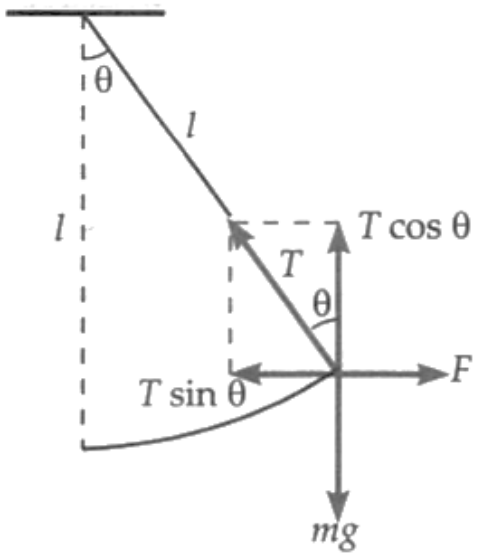
19. A force F = $\left[3x^2\,\hat{\mathbf{i}} + 4\hat{\mathbf{j}}\right]$ N where *x* in metres, acts on a particle. How much work is done on the particle if it is moved from coordinates (2m, 3m) to (3m, 0m)? **[2]**

20. Find the angle between force $(\mathbf{F} = 3\hat{\mathbf{i}} + 4\hat{\mathbf{j}} - 5\hat{\mathbf{k}})$ unit and displacement $(\mathbf{d} = 5\hat{\mathbf{i}} + 4\hat{\mathbf{j}} + 3\hat{\mathbf{k}})$ unit. Also, find the projection of **F** on **d**. **[2]**

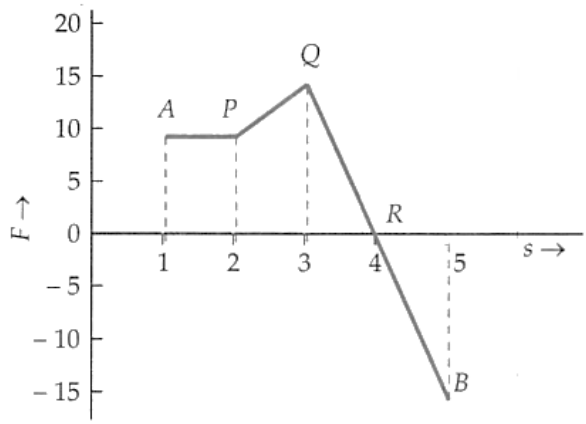
21. Calculate the work done by a car against gravity in moving along a straight horizontal road. The mass of the car is 400 kg and the distance moved is 2m. **[2]**

22. A person is holding a bucket by applying a force of 10 N. He moves a horizontal distance of 5 m and then climbs up a vertical distance of 10 m. Find the total work done by him. **[2]**

23. A small object of weight mg hangs from a string of length l, as shown in Fig. A variable force F, which starts at zero and gradually increases is used to pull the object very slowly (so that equilibrium exists at all the times) until the string makes an angle θ with the vertical. Calculate the work done by force F. **[2]**



24. A body moves from point A to B under the action of a force, varying in magnitude as shown in Fig. Obtain the work done. Force is expressed in newton and displacement in metre. **[2]**



25. A coolie is holding a bag by applying a force of 15 N. He moves forward and covers the horizontal distance of 8 m and then he climbs up and covers the vertical distance of 10 m. What will be the work done by him? **[2]**

The net work done by coolie is the sum of work done to cover the horizontal direction and the work done to climb up in the vertical direction.

26. Give three important characteristics of conservative forces. **[2]**

27. How do you calculate the work done by a variable force? **[2]**

28. Find the work done by force $\vec{F} = 2\hat{i} - 3\hat{j} + \hat{k}$ when its point of application moves from the point A (1, 2, -3) to the point B (2, 0, -5). **[2]**

29. A body of mass 0.5 kg travels in a straight line with velocity $v = ax^{3/2}$, where $a = 5m^{-\frac{1}{2}} s^{-1}$. What is the work done by the net force during its displacement from x=0 to x=2m? **[2]**

30. Two identical 5 kg blocks are moving with same speed of 2 ms^{-1} towards each other along a frictionless horizontal surface. The two blocks collide, stick together and come to rest. Consider the two blocks as a system. Calculate work done by **[2]**

i. external forces and

ii. internal forces.

31. A particle is acted upon by constant forces $\overrightarrow{F_1} = 2\hat{i} - 3\hat{j} + 4\hat{k}$ and $\overrightarrow{F_2} = -\hat{i} + 2\hat{j} - 3\hat{k}$, is displaced from the point A (2, 1, 0) to the point B (-3, -4, 2). Find the total work done by these forces. **[2]**

32. A locomotive of mass m starts moving so that its velocity varies according to the law $v = \alpha\sqrt{s}$, where a is a constant and s is the distance covered. Find the total work done by all the forces acting on the locomotive during the first t seconds after the beginning of motion. **[2]**

33. A man rowing boat upstream is at rest with respect to the shore. Is he doing work? **[2]**

34. A particle of mass m is moving in a horizontal circle of radius r, under a centripetal force equal to $-\left(\frac{K}{r^2}\right)$, where K is constant. What is the total energy of the particle? **[2]**

35. A block of mass m = 1 kg, moving on a horizontal surface with speed $v_i = 2$ ms^{-1} enters a rough patch ranging from x = 0.10 m to x = 2.01 m. The retarding force F_r on the block in this range is inversely proportional to x over this range, **[2]**

$F_r = \frac{-k}{x}$ for 0.1 < x < 2.01 m

= 0 for x < 0.1m and x > 2.01 m

where k = 0.5 J. What is the final kinetic energy and speed v_f of the block as it crosses this patch?

36. A particle is moving in a circular path of a given radius with a number of rotations per second **[2]**

i. constant,

ii. increasing,

iii. decreasing.

What happens to work done in the three cases?

37. Calculate the work done in raising a stone of mass 5 kg and specific gravity 3, lying at the bed of a lake through a height of 5 m. **[2]**

38. A 0.5 kg particle moves along the x-axis from x = 5 m to x = 17.2 m under the influence of a force F(x), **[2]**

$F = \frac{200}{2x+x^3}$ N

Estimate (with at least 5% accuracy) the total work done by this force during this displacement.

39. A force $\vec{F} = (2\hat{i} - 6\hat{j})$N is applied on a body, which is sliding over a floor. If the body is displaced through $(-3\hat{j})$ m, how much work is done by the force? **[2]**

40. What do you mean by positive work and negative work? Give examples. **[2]**

41. What are conservative and non-conservative forces? Give one example of each. **[2]**

42. A boy has a bag of sand of mass 20 kg. First of all, he keeps the bag on his head and moves 10 m. Second time, he drags the bag through 10 m on a frictionless surface with coefficient of friction μ = 0.1. In which case, he does more work? **[2]**

Section C

43. **Fill in the blanks:** **[3]**

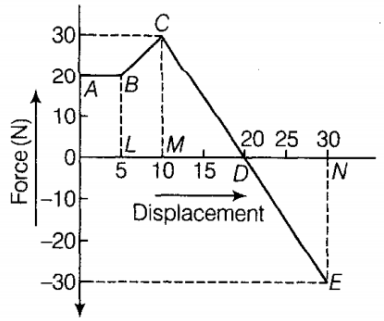
    (a) When a body is moving along a circular path, the work done by the centripetal force is _____. **[1]**

    (b) Gravitation force is a _____ force while force of friction is a _____ force. **[1]**

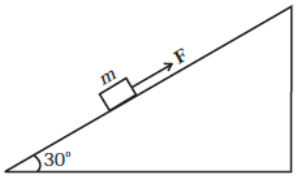
    (c) The work done in holding 15 kg suitcase while waiting for a bus for 15 minutes is _____. **[1]**

44. A woman pushes a trunk on a railway platform which has a rough surface. She applies a force of 100 N over a distance of 10 m. Thereafter, she gets progressively tired and her applied force reduces linearly with distance to 50 N. The total distance through which the trunk has been moved is 20 m. Plot the force applied by the woman and the frictional force, which is 50 N versus displacement. Calculate the work done by the two forces over 20 m. **[3]**

45. The force applied by a man in pushing a block varies with displacement as shown in the figure. If the force is expressed in Newton and displacement in meters, find the work done by him. **[3]**



46. A wooden block of mass 1 kg is pushed up a surface inclined to horizontal at an angle of 30° by a force of 10 N parallel to the inclined surface [see figure]. The coefficient of friction between the block and the incline is 0.1. If the block is pushed up by 10 m along the incline. Calculate **[3]**



i. Work done against gravity.

ii. Work done against force of friction.

iii. Acceleration of block when it moves upward.

47. What is a variable force? Find work done by a variable force graphically. **[3]**

48. A person trying to lose weight (dieter) lifts a 10 kg mass, one thousand times, to a height of 0.5 m each time. Assume that the potential energy lost each time she lowers the mass is dissipated. **[3]**

    a. How much work does she do against the gravitational force?

    b. Fat supplies 3.8×10^7 J of energy per kilogram which is converted to mechanical energy with a 20% efficiency rate. How much fat will the dieter use up?

49. A body of mass of 2 kg initially at rest moves under the action of an applied horizontally force of 7 N on a table with coefficient of kinetic friction = 0.1. Compute the **[3]**

i. work done by the applied force in 10 s,

ii. work done by friction in 10 s,

iii. work done by the net force on the body in 10 s,

Section D

Question No. 50 to 53 are based on the given text. Read the text carefully and answer the questions: **[4]**

In everyday life, the term work is used to refer to any form of activity that requires the exertion of mental or muscular efforts. In physics, work is said to be done by a force or against the direction of the force, when the point of application of the force moves towards or against the direction of the force. If no displacement takes place, no work is said to be done.

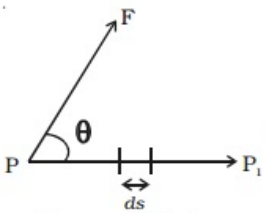


Fig. Work done by a force

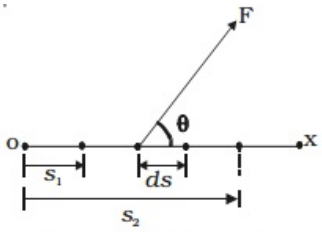
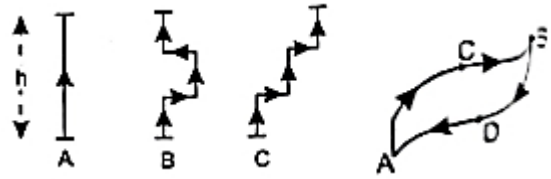


Fig. Work done by a constant force

50. A box is pushed through 4.0 m across a floor offering 100 N resistance. How much work is done by the applied force?
51. What do you mean by non conservative forces, give an example.
52. What is the work done to revolve the body with constant speed in a circle?
53. Force of 4N is applied on a body of mass 20 kg in the direction of motion. What will be the work done in displacing the body through 3 m ?

Question No. 54 to 57 are based on the given text. Read the text carefully and answer the questions: **[4]**

In nature we have various types of forces. A force is said to be a conservative force if work done by (or against) the force for moving an object from one position to another position depends on these two initial and final) points but is independent of other factors like the nature of path followed or velocity of object. It is also found that work done on an object against the conservative force present there gets stored up as the potential energy of the object. When external constraints are removed, the stored potential energy manifests itself as kinetic energy. lf above mentioned conditions are not fulfilled then force is called a non-conservative force.



54. Give two examples of conservative forces.
55. Three girls of same mass climb through a certain height h' following different paths shown as A, B and C in the figure. In which case is the work done against gravity maximum and in which case it is minimum?
56. An object is taken from position A to B via a path ACB and then brought back to position A via another path BDA. If the force involved is a conservative force, then show that net work done for entire closed path is zero.
57. What is a non conservative force? Give two examples

Section E

Question No. 58 to 62 are based on the given text. Read the text carefully and answer the questions: **[5]**

In everyday life, the term work is used to refer to any form of activity that requires the exertion of mental or muscular efforts. In physics, work is said to be done by a force or against the direction of the force, when the point of application of the force moves towards or against the direction of the force. If no displacement takes place, no work is said to be

done.

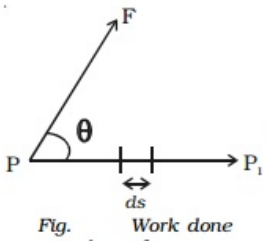


Fig. Work done by a force

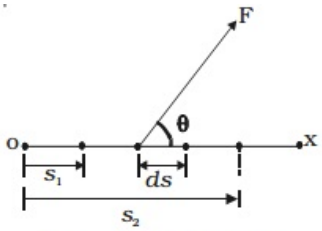


Fig. Work done by a constant force

58. A box is pushed through 4.0 m across a floor offering 100 N resistance. How much work is done by the applied force?

a) 100 J b) 300 J

c) 400 J d) 200 J

59. What is work done in holding a 15 kg suitcase while waiting for 15 minutes?

a) 22.5 J b) zero

c) 225 J d) 150 J

60. Frictional forces are:

a) conservative forces b) non-conservative forces

c) buoyant force d) non buoyant force

61. When the body moves in a circular motion, net 'work' done is:

a) one b) positive

c) negative d) zero

62. Force of 4N is applied on a body of mass 20 kg. The work done in 3rd second is:

a) 6 J b) 8 J

c) 4 J d) 2 J

63. A body of mass 0.3 kg is taken up an inclined plane to length 10 m and height 5 m, and then allowed to slide down to the bottom again. The coefficient of friction between the body and the plane is 0.15. What is the **[5]**

i. work done by the gravitational force over the round trip,

ii. work done by the applied force over the upward journey,

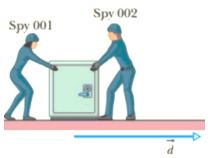
iii. work done by frictional force over the round trip,

iv. kinetic energy of the body at the end of the trip?

How is the answer to (iv) related to the first three answers?

64. Obtain mathematically and graphically the work done by a variable force. **[5]**

65. Figure shows two industrial spies sliding an initially stationary 250 kg floor safe, a displacement d of magnitude 10 m, straight towards their truck. The push F_1 of spy A is 15 N directed at an angle of 30^o downward from the horizontal, the pull F_2 of spy B is 12 N directed at 40^o above the horizontal plane. **[5]**



The magnitudes and direction of these forces do not change as the safe moves, and the floor and safe make frictionless contact. [tan 40^o = 0.8390, sin 40^o = 0.6427]

i. What is the net work done on the safe by forces F_1 and F_2 during the displacement d?

ii. During the displacement, what is the work W_g done on the safe by the gravitational force F_g and what is the work W_N done on the safe by normal F_N from the floor?

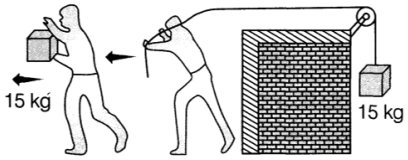
66. i. The casing of a rocket in flight burns up due to friction. At whose expense is the heat energy required for burning obtained? The rocket or the atmosphere. **[5]**

ii. Comets move around the Sun in highly elliptical orbits. The gravitational force on the comet due to the Sun is not normal to the comet's velocity in general. Yet the work done by the gravitational force over every complete orbit of the comet is zero. Why?

iii. An artificial satellite orbiting the Earth in very thin atmosphere loses its energy gradually due to dissipation against atmospheric resistance, however small. Why does its speed increase progressively as it comes closer and closer to the earth?

iv. In Fig. (a) the man walks 2 m carrying a mass of 15 kg on his hands. In Fig. (b) he walks the same distance pulling the rope behind him.

The rope goes over a pulley and a mass of 15 kg hangs at its other end. In which case is the work done greater?



67. **Read the case study given below and answer any four subparts:** **[5]**

In everyday life, the term work is used to refer to any form of activity that requires the exertion of mental or muscular efforts. In physics, work is said to be done by a force or against the direction of the force, when the point of application of the force moves towards or against the direction of the force. If no displacement takes place, no work is said to be done.

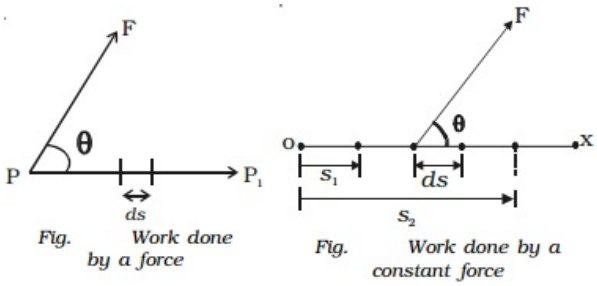


Fig. Work done by a force

Fig. Work done by a constant force

i. A box is pushed through 4.0 m across a floor offering 100 N resistance. How much work is done by the applied force?

a. 100J

b. 200 J

c. 300 J

d. 400 J

ii. What is work done in holding a 15 kg suitcase while waiting for 15 minutes?

a. 22.5 J

b. 225 J

c. zero

d. 150 J

iii. Frictional forces are:

a. conservative forces

b. non- conservative forces

c. buoyant force

d. none of these

iv. When the body moves in circular motion, net 'work' done is:

a. positive

b. negative

c. zero

d. none of these

v. Force of 4N is applied on a body of mass 20 kg. The work done in 3rd second is:

a. 2J

b. 4J

c. 6J

d. 8J

Section F

68. **State True or False:** **[6]**

(a) Work done by a force is zero, if the body gets displaced in the direction perpendicular to the direction of the force applied. **[1]**

(b) For uniform circular motion, no work is done but a centripetal acceleration is present. **[1]**

(c) For a particular displacement, work done by a force is independent of the type of motion i.e., whether it moves with constant velocity, constant acceleration or retardation. **[1]**

(d) The amount of work does not depend upon the fact that how fast is a load raised or moved in the direction of force. **[1]**

(e) The earth moving around the sun in a circular orbit is acted upon by a force and hence work must be done on the earth by this force. **[1]**

(f) If a force acting on a body has a component in the opposite direction of displacement, then work done is positive. **[1]**