Chapter- 6

WORK ENERGY AND POWER

01. Does the sun do any work on earth, when earth revolves around the sun in a perfectly circular orbit?

02. Does the K.E. depend upon the direction of motion involved? Can it be negative? Does its value depend on the frame of reference?

03. Name the largest and smallest practical unit of energy.

04. Is work done by a non-conservative force always negative? Comment.

05. When P.E of an object be negative?

06. A force $\vec{F} = 6x\hat{i} + 2y\hat{j}$ displaces a body from $\vec{r_1} = 3\hat{i} + 8\hat{j}$ to $\vec{r_2} = 5\hat{i} - 4\hat{j}$, Find the work done by the force.

07. What is restoring force in a spring?

08. A spring is cut into two halves. How is the spring constant of each half affected?

09. Give the conditions for the conservative force with examples.

10. What are elastic and inelastic collisions?

11. What is the common feature of all types of collisions?

12. In which of the two types of collisions elastic or inelastic is the momentum conserved? What about K.E?

13. What is the coefficient of restitution?

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

15. What should be the angle between the constant force and the displacement for maximum and minimum work?

16. Give one example each of the following (a) zero work (b) negative work.

17. Find the work done in moving a particle through the displacement $\vec{S}=(4\hat{i}-\hat{j}+7\hat{k})$ of the meter if the applied force is the $\vec{F}=(\hat{i}+2\hat{j}-\hat{k})$ newton.

18. Out of joule, calorie, kilowatt, and electron volt, which one is not the unit of energy?

19. What is the relation between energy and momentum?

20. Two bodies having unequal masses possess equal kinetic energies. Which one has more momentum?

21. A force $F = a + bx$ acts on a particle in x-direction where a and b are constant. Find the work from x_1 to x_2.

22. A light and a heavy body have equal kinetic energies of translation. Which one has lesser momentum? justify.

23. State the work-energy theorem for a variable force.

24. Derive an expression for the gravitational potential energy of a body lying at a height h (h<<R, the radius of the earth) above the surface of the earth.

25. Derive an expression for the potential energy stored in a system of a block attached to a massless spring, when the block is pulled from its equilibrium position.

26. Show that the total mechanical energy of a body falling freely under gravity is conserved.

27. What is the total mechanical energy associated with a mass m at rest at height h? If it is dropped to the ground, how does its P.E and K.E change? Explain diagrammatically. (Ignore air resistance and variation of acceleration due to gravity).

28. (a)What is a conservative force? Explain its various properties.

(b)What is a non-conservative force? Explain with examples.

29. In a ballistic demonstration, a police officer fires a bullet of mass 50 gm. Which speed 200 m/s on soft plywood of thickness 2 cm. The bullet emerges with only 10% of its initial Kinetic Energy. What is the emergent speed of the bullet?

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

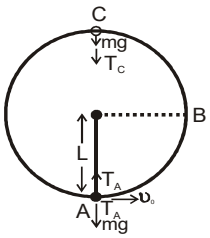
31. Prove that when two bodies of equal masses undergo elastic collision in one dimension, their velocities are just interchanged.

32. Two ball bearings of mass m each moving in opposite directions with equal speed collide head-on with each other. Predict the outcome of the collision, assuming it to be perfectly elastic.

33. Discuss the elastic collision of two bodies in one dimension. Calculate the velocities of the bodies after the collision. Discuss what happens when both the bodies are of equal mass.

34. A block of mass = 1 kg moving on a horizontal surface with speed v_i=2 m/s enters a rough patch ranging from x = 0.1m to x = 2.01 m. The retarding force F_r on the block in the range is $F_r = \frac{-k}{x}$, for $0.1 < x < 2.01\,m$ and F_r =0 for x < 0.1m and x > 2.01m. where k=0.5 J. what is the final KE and speed v_f of the block as it crosses this patch?

35. A bob of mass m is suspended by a light string of L. It is imparted a horizontal velocity v_0 at the lowest point A such that it completes a semicircular trajectory in the vertical plane with the string becoming just slack only on reaching the topmost point, C.



Obtain an expression for.

(i) v_0

(ii) the speeds at points B and C

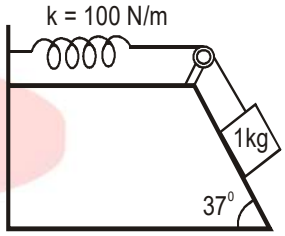
(iii) the ratio of the kinetic energies (K_B/ K_C) at B and C. Comment on the nature of the trajectory of the bob after it reaches point C.

36. a) Derive potential energy of a spring constant 'K'?

(b) The draw spring force and distance graph of a spring?

(c) Draw potential energy, PE, KE, TE Vs position graph of a spring.

37. A 1kg block situated on a rough incline plane is connected to a spring of spring constant 100Nm^{-1} as shown in the figure. The block is released from rest with the spring in the unstretched position. The block moves 10 cm down the incline before coming to rest. Find the coefficient of friction between the block and the incline. Assume that the spring has negligible mass and the pulley is frictionless.



38. A well 20 m deep and 3m in diameter contains water to a depth of 14m. how long will 5 hp engine take to empty it?

39. A pump on the ground floor of a building can pump up water to fill a tank of volume 30 m^3 in 15 min. If the tank is 40 m above the ground and the efficiency of the pump is 30%, how much electric power is consumed by the pump?

40. An airplane flying in the skydives with a speed of 360 km/h in a vertical circle of radius 200 m, the weight of the pilot sitting in it is 75 Kg. Calculate the force with which the Pilot presses his seat when the aeroplane is (1) at the highest position (2) at the lowest position of the circle, Take g = 10m/s^2.

41. A body weighing 0.5 kg tied to a string is projected with a velocity of 10 m/s. The body starts whirling in a vertical circle. If the radius of a circle is 0.8 m find the tension in the string when the body is (1)at the top of the circle and (2) at the bottom of the circle.
42. What percentage of the kinetic energy of a moving particle is transferred to a stationary particle when the moving particle strikes with a stationary particle of mass (i) 19 times it's the mass (ii) equal in mass (iii)1/9 th of its mass.
43. Show that when a moving body collides with a stationary body of mass m or 1/m times its mass, then the moving body transfers $\frac{4m}{(1+m)^2}$ part of its kinetic energy to the stationary body.
44. A cyclist comes to a skidding stop at 10m. During this process, the force on the cycle due to the road is 200 N and is directly opposed to the motion.

    (a) How much work done the road do on the cycle?

    (b) How much work does the cycle do on the road?

45. A particle moves along X-axis from x = 0 to x = 3 under the influence of a force given $F = 7 - 2x + 3x^2$. Find the work done in the process.
46. A man moves on a straight horizontal road with a block of mass 2kg in his hand. If he covers a distance of 40 m with an acceleration of 0.5 m/s^2, find the work done by the man on the block during the motion.
47. A woman pushes a trunk on a railway platform which has a rough surface. She applies a force of 100N. Over a distance of 10m. Then she gets tired and her applied force reduces linearly with distance to 50N. The total distance moved by trunk is 20m. Plot the force applied by the women and the frictional force. Which is 50N versus displacement? Find the work done by the two forces over 20m.
48. A shot travelling at the rate of 100 m/s in just able to pierce a plank 4cm thick. What velocity is required to just pierce a plank 9cm thick?
49. Two identical 5kg blocks are moving with the same speed 2m/s towards each other along with the frictionless horizontal surface. The two blocks collide, stick together, and come to rest. Consider the two blocks as a system. Find work done by (i) External Force (ii) Internal Force.
50. A vehicle of mass 15 quintal climbs up a hill 200m high. It then moves on a level road with a speed of 30 m/s. Find the Potential energy gained by it and its total mechanical energy while running on top of the hill.

51. A girl of mass 40 kg sits in as wing formed by a rope of 6m length. A person pulls the swing to a side so that the rope makes an angle of 60^0 with the vertical. What is the gain in the potential energy of girl?
52. A bullet of mass 10 g travels horizontally with a speed of 100 m/s and is absorbed by a wooden block of mass 500 g suspended by a string. Find the vertical height through which the block rises. $\left(g = 10 m / s^2\right)$
53. A ball falls under gravity from a height of 10m with an initial downward velocity u. it collides with the ground and loses 50% of its energy in a collision and then rises back to the same height. Find the initial velocity u.
54. A car of mass 2000 kg is lifted up a distance of 30 m by a crane in 1 min. A 2nd crane does the same job in 2 min. Do the cranes consume the same or different amounts of fuel? What is the power supplied by each crane? (Neglect power dissipation against friction)
55. A car of mass 1000 kg accelerates uniformly from rest to a velocity of 54 km/h in 5 seconds. Find (i) its acceleration (ii) it's gain in K.E (iii) Average power of the engine during this period by neglecting friction.
56. A body is moving unidirectionally under the influence of a source of constant power. Its displacement in time t is proportional to ___?
57. A particle of mass 0.5 kg travels in a straight line with velocity $V = ax^{3/2}$, where $a = 5 m^{-1/2}.s^{-1}$. What is work done by the net force during its displacement from x = 0 to x = 2m.
58. A spring gun has a spring constant of 80 N/cm. The spring is compressed 12 cm by a ball of mass 15g. How much is the potential energy of the spring? If the trigger is pulled, what will be the velocity of the ball be?
59. A block of mass 2kg initially at rest is dropped from a height of 1m into a vertical spring having a force constant 490 N/m. Find the maximum distance through which the spring will be compressed.
60. A block of mass 2kg is dropped from a height of 40 cm on a spring whose force constant is 1960 N/m. What will be the maximum distance x through which the spring is compressed?

61. A bolt of mass 0.3 kg falls from the ceiling of an elevator moving down with a uniform speed of 7ms^{-2}. It hits the floor of the elevator (length of the elevator = 3m) and does not rebound. What is the heat produced by the impact? Would your answer be different if the elevator were stationary?
62. 230 joules were spent in lifting a 10 kg weight to a height of 2m. Calculate the acceleration with which it was raised. Take g = 10ms^{-2}
63. A bullet of mass 10 g travels horizontally with a speed of 100ms^{-1} and is absorbed by a wooden block of mass 990 g suspended by a string. Find the vertical height through which the block rises. Take $g = 10\,\text{ms}^{-2}$
64. A simple pendulum of length 1m has a wooden bob of mass 1kg. It is struck by a bullet of mass 10^{-2} kg moving with a speed of $2\times10^{2}\,\text{ms}^{-1}$. The bullet gets embedded into the bob. Obtain the height to which the bob rise before swinging back. Take $g = 10\,\text{ms}^{-2}$
65. In a Circus, the diameter of the globe of death is 20m, From what minimum height must a cyclist start in order to go round the globe successfully?
66. A weightless thread can bear tension up to 3.7 Kgwt. A stone of mass 500 g is tied to it and revolves in a circular path of radius 4 m in a vertical plane .if g= 10 m/s^2 , then what will be the maximum angular velocity of the stone?
67. A stone is tied to a weightless string and revolved in a vertical circle of radius 5m.(i)What should be the minimum speed of the stone at the highest point of the circle so that the string does not slack? (ii) What should be the speed of the stone at the lowest point in this situation? Take g =9.8 m/s^2
68. Two ball bearings of mass m each moving in opposite directions with equal speed v collides head-on with each other. Predict the outcome of the Collision, assuming it to be perfectly elastic.
69. Two bodies of masses 5 kg and 3 kg moving in the same direction along the same straight line with velocities 5 m/s and 3 m/s respectively suffer a one-dimensional elastic collision. Find their velocities after the collision.
70. A 10 kg ball and 20 kg ball approach each other with velocities 20m/s and 10 m/s respectively. What are their velocities after a collision if the collision is perfectly elastic.

71. What percentage of the kinetic energy of a moving particle is transferred to a stationary particle, when the moving particle strikes with a stationary particle of mass (i) 9 times in mass(ii) equal in mass (iii) 1/19 th of its mass.
72. What percentage of the K.E of a moving particle is transferred to a stationary particle when it strikes the stationary particle of four times of its mass.
73. Two particles of masses 0.5kg and 0.25 kg moving with velocities 4 m/s and 3 m/s collide head-on in a perfectly inelastic Collision. Find (1) the velocity of the composite particle after the collision and (ii) the kinetic energy lost in the collision.