CLASS 9 SCIENCE

CHAPTER 7

WORK, ENERGY, AND SIMPLE MACHINES

NCERT QUESTIONS & ANSWERS

Chapter coverage: Work done by a constant force • positive, negative and zero work • work-energy theorem • forms of energy • kinetic energy • potential energy • conservation of mechanical energy • power • pulley, inclined plane and lever.

Source basis: Prepared from the supplied NCERT Grade 9 *Exploration* Chapter 7 and its chapter-end “Revise, Reflect, Refine” exercise. The textbook identifies Chapter 7 as “Work, Energy, and Simple Machines.” ■filecite■turn166file0■L13-L27■

CHAPTER-END QUESTIONS & ANSWERS

Revise • Reflect • Refine — Chapter 7

1. State whether True or False: (i) Work is done when a force is applied even if the object does not move. (ii) Lifting a bucket vertically upward results in positive work. (iii) SI unit of work and energy is joule. (iv) A motionless stretched rubber band has kinetic energy. (v) Energy can change from one form to another.

Answer:
(i) **False** — work requires displacement in the direction of the force.
(ii) **True** — applied force and displacement are upward.
(iii) **True** — both have SI unit joule (J).
(iv) **False** — a motionless stretched rubber band has stored potential energy, not kinetic energy.
(v) **True** — energy can be transformed from one form to another.

2. Fill in the blanks: (i) Work done = ___ × ___ (in the direction of force). (ii) 1 J of work is done when a force of ___ N displaces an object by 1 m in the direction of force. (iii) Kinetic energy of mass m moving with velocity v is ___. (iv) Potential energy at height h is ___. (v) Power is the ___ at which work is done.

Answer:
(i) **Force × displacement**
(ii) **1 N**
(iii) **$\frac{1}{2}mv^2$**
(iv) **mgh**
(v) **rate**.

3. When a ball thrown upwards reaches its highest point, which statements are correct? (i) Force acting is zero. (ii) Acceleration is zero. (iii) Kinetic energy is zero. (iv) Potential energy is maximum.

Answer: (iii) and (iv).
At the highest point, the instantaneous velocity is zero, so kinetic energy is zero. Gravity still acts downward, so the force and acceleration are not zero. The ball is at its greatest height, so gravitational potential energy is maximum.

4. Identify the energy transformation: (i) truck moving uphill, (ii) unwinding watch spring, (iii) photosynthesis, (iv) water flowing from a dam, (v) burning matchstick, (vi) fire cracker explosion, (vii) speaking into a microphone, (viii) glowing electric bulb, (ix) solar panel.

Answer:
(i) Kinetic $\rightarrow$ gravitational potential energy.
(ii) Elastic potential $\rightarrow$ kinetic energy (and then mechanical motion).
(iii) Solar/light $\rightarrow$ chemical energy.
(iv) Gravitational potential $\rightarrow$ kinetic energy.
(v) Chemical $\rightarrow$ thermal and light energy.
(vi) Chemical $\rightarrow$ thermal, light, sound and kinetic energy.
(vii) Mechanical/sound $\rightarrow$ electrical signal.
(viii) Electrical $\rightarrow$ light and thermal energy.
(ix) Solar/light $\rightarrow$ electrical energy.

5. A 50 kg student is lifted to a height of 72.5 m. Take g = 10 m s■^{2}. Find the gain in potential energy when lifted straight up, when climbing the stairs, and state whether potential energy depends on path.

Given: m = 50 kg, h = 72.5 m, g = 10 m s■^{2}.
Potential energy gained = mgh = 50 × 10 × 72.5 = **36,250 J**.
(i) Elevator: **36,250 J**.
(ii) Stairs: **36,250 J**.
(iii) Therefore, gravitational potential energy depends on the initial and final heights, **not on the path taken**.

Exam Tip: For numericals, write the given quantities with SI units, choose the relevant energy/work formula, show substitution clearly, and state the final unit and direction where needed.

6. A crane lifts a mass m to the 10th floor in a certain time and then to the 20th floor in double the time. How much more energy and power are required?

Answer: The 20th floor is twice the height of the 10th floor. Since gravitational potential energy is mgh, the required energy is **twice** the original energy. But the time is also doubled. Since P = W/t, the power remains **the same**.
Answer: Energy = 2 times; power = same.

7. What factors determine the energy required to raise a flag using a pulley? Does raising it slowly or quickly change the work? If speed is doubled, how does power change?

Answer: The energy required depends on the **mass of the flag, gravitational acceleration and height raised**: $\Delta U = mgh$ (ignoring losses). Raising it slowly or quickly does not change the work required for the same load and height. If the speed is doubled while the same work is done in half the time, the **power doubles**.

8. A man of mass 60 kg rides a 100 kg scooter. Next day his 40 kg son joins him. Both reach the same speed in the same time. Find the ratio of fuel used.

First day total mass: 100 + 60 = 160 kg.
Second day total mass: 100 + 60 + 40 = 200 kg.
For the same final speed from rest, kinetic energy is proportional to mass: $K = \frac{1}{2}mv^2$. Therefore fuel energy required is in ratio 160:200 = **4:5**.
Answer: 4:5.

9. On a seesaw, an adult weighs twice as much as a child, but the seesaw is balanced. Show where they should sit relative to the fulcrum.

Answer: For balance, clockwise moment = anticlockwise moment.
Let the child's weight be W and distance from fulcrum be d. Adult weight = 2W. If the adult sits at distance D:
$W \times d = 2W \times D$
so $\mathbf{d = 2D}$.
Therefore, the child should sit twice as far from the fulcrum as the adult. A suitable distance ratio is **child : adult = 2 : 1**.

10. A 2 kg ball is thrown upward at 20 m s■^{1}. (i) Identify the sign of work done by gravity upward and downward. (ii) If it reaches 19.4 m, find work done by air resistance. Take g = 10 m s■^{2}.

(i) During upward motion, gravity is opposite to displacement, so work is **negative**. During downward motion, gravity and displacement are in the same direction, so work is **positive**.
(ii) Initial kinetic energy = $\frac{1}{2} \times 2 \times 20^2 = 400$ J. Potential energy gained at 19.4 m = $2 \times 10 \times 19.4 = 388$ J. Without air resistance, these would be equal; the difference is due to air resistance. Thus work done by air resistance = 388 – 400 = –**12 J**.

> **Exam Tip:** For numericals, write the given quantities with SI units, choose the relevant energy/work formula, show substitution clearly, and state the final unit and direction where needed.

11. A 10 kg block has an initial kinetic energy of 180 J. A variable force acts from 0 m to 4 m as shown in Fig. 7.37. Find its speed at 0 m and 4 m, and state whether it has negative acceleration anywhere.

(i) At 0 m: $180 = \frac{1}{2}(10)v^2$, so $v^2 = 36$ and **v = 6 m s■^{1}**.
(ii) At 4 m: From the force-displacement graph, the work done over 0–4 m is 150 J. Hence final kinetic energy = 180 + 150 = 330 J.
$330 = \frac{1}{2}(10)v^2 \Rightarrow v^2 = 66 \Rightarrow$ **v = √66 m s■^{1}**.
(iii) No. The applied force does not become negative, so the block does not have negative acceleration in the shown motion.

12. Lunar gravity is about 1/6 of Earth's gravity. An astronaut can throw a ball to 8 m on Earth. How high will the same ball travel on the Moon with the same initial velocity?

Answer: 48 m.
For upward motion, $v^2 = u^2 - 2gh$. At the highest point v = 0, so $u^2 = 2gh$. For the same initial velocity, u^2 is the same. Hence h is inversely proportional to g. Since $g_{Moon} = g_{Earth}/6$,
$\mathbf{h_{Moon} = 6 \times 8 = 48}$ **m.**

13. A 1000 kg car moves at constant speed. The speed-time graph shows the car before and during braking. (i) Describe motion between A and B. (ii) Calculate KE at A. (iii) Work done by brakes between B and C. (iv) What does KE transform into?

Answer:
(i) Between A and B the car moves with **constant speed** (35 m s■^{1} as shown).
(ii) $K = \frac{1}{2}mv^2 = \frac{1}{2} \times 1000 \times 35^2 =$ **612,500 J**.
(iii) The car comes to rest at C, so change in KE = 0 – 612,500 = –**612,500 J**. Therefore the brakes do –**612,500 J** of work.
(iv) The kinetic energy is mainly transformed into **thermal energy** due to friction in the braking system and tyres/road.

14. A 0.5 kg ball moves on a frictionless track. At O its velocity is zero and potential energy is 30 J. Use the potential-energy graph to find velocity at P, Q and R.

Answer: Mechanical energy remains constant at 30 J because the track is frictionless.
At **P**, the graph gives the corresponding potential energy such that kinetic energy is 10 J; hence $\frac{1}{2}mv^2 = 10 \Rightarrow$ **v = 2√10 m s■^{1}**.
At **Q**, the potential energy is 30 J, so kinetic energy is zero ⇒ **v = 0 m s■^{1}**.
At **R**, the potential energy is higher than the total available mechanical energy, so the ball **cannot reach position R**.

15. A 1.5 kg coconut falls from a 10 m tree. It stops in wet sand. Average resistive force of sand is 3000 N; g = 10 m s■^{2}. Find (i) speed just before impact, (ii) depth of depression.

(i) Using $v^2 = u^2 + 2gh$, with u = 0:
$v^2 = 2 \times 10 \times 10 = 200$, so **v = 10√2 m s■^{1}** downward.
(ii) Energy just before impact = mgh = 1.5 × 10 × 10 = 150 J. This energy is used against the sand's resistive force: W = Fd.
3000d = 150 ⇒ **d = 0.05 m = 5 cm**.
Answer: 10√2 m s■^{1}; 0.05 m.

> **Exam Tip:** For numericals, write the given quantities with SI units, choose the relevant energy/work formula, show substitution clearly, and state the final unit and direction where needed.

QUICK REVISION — CHAPTER 7

High-priority concepts, laws and formulas

Work: $W = F \times s$ when displacement is in the direction of the force. SI unit = joule (J). Work can be positive, negative or zero. Work is zero when there is no displacement, no force, or the force is perpendicular to displacement in the situations described in the chapter.

Work-Energy Theorem: Work done on an object = change in its energy. **Kinetic energy:** $K = \frac{1}{2}mv^2$. **Gravitational potential energy:** $U = mgh$.

Mechanical energy: $E = K + U$. In the absence of other external forces, mechanical energy remains constant. During free fall, potential energy decreases while kinetic energy increases by the same amount.

Power: $P = W/t$. SI unit = watt (W), where 1 W = 1 J s^{-1}. For the same work, reducing the time increases power.

Simple machines: Pulley, inclined plane and lever help make tasks easier by changing the magnitude or direction of the force. They do not reduce the total work required when friction is ignored. The effort is the applied force and the load is the force to be overcome.

Key answers: Q1 F, T, T, F, T • Q2 Force; displacement; 1; $\frac{1}{2}mv^2$; mgh; rate • Q3 (iii), (iv) • Q5 36,250 J; 36,250 J; path-independent • Q6 energy twice, power same • Q8 4:5 • Q10 –12 J • Q11 6 m s^{-1}; $\sqrt{66}$ m s^{-1}; No • Q12 48 m • Q13 612,500 J; –612,500 J • Q14 $2\sqrt{10}$ m s^{-1}; 0 m s^{-1}; cannot reach R • Q15 $10\sqrt{2}$ m s^{-1}; 0.05 m.