



Attempt questions first; check the separate key afterward. Take $g = 10 \text{ m/s}^2$ where needed. Neglect air resistance unless stated.

A. Very short answers - 1 mark each

1. Define work by a constant force and state when it is zero.
2. Can work be negative? Give a physical example.
3. Why does centripetal force do no work in uniform circular motion?
4. State the work-energy theorem.
5. Define instantaneous power and give its SI unit.
6. What distinguishes a conservative force from a non-conservative force?
7. Which quantities are conserved in an isolated perfectly elastic collision?
8. What happens to potential energy when a conservative force does positive work?

B. Short answers / practice - 2 marks each

9. A 10 N force acts at 60° to a displacement of 5 m. Calculate its work.
10. A 2 kg body speeds up from 3 to 7 m/s. Find the net work done.
11. A 500 W motor lifts 20 kg vertically at steady speed. Find the speed, neglecting losses.
12. A spring of constant 200 N/m is compressed by 0.10 m. Find its stored energy and maximum restoring force.
13. A 1 kg block slides 4 m under a constant friction force of 3 N. Find work by friction and the loss in mechanical energy.
14. A force $F = 4x$ acts along x (SI units). Find its work between $x = 0$ and 3 m.
15. A body's momentum doubles at unchanged mass. How do kinetic energy and speed change?
16. Two bodies have equal kinetic energies and masses in the ratio 1:4. Find their momentum and speed ratios.

C. Application / reasoning - 3 marks each

17. A 2 kg block falls from rest through 5 m. Using energy conservation, find its speed and kinetic energy just before impact.
18. A 4 kg block moving at 5 m/s stops on a rough floor with $\mu_k = 0.25$. Find stopping distance using energy.
19. A force increases linearly from 10 N to 30 N over 4 m. Find its work from an F - x graph and the speed gained by a 2 kg body initially at rest.

20. A 2 kg body at 6 m/s sticks to a stationary 4 kg body. Find final speed and kinetic energy lost.

21. A 1 kg body moving at 5 m/s collides head-on elastically with an identical stationary body. Find both final velocities and explain energy transfer.

22. A spring with $k = 400 \text{ N/m}$ launches a 0.5 kg block from a compression of 0.10 m on a smooth horizontal floor. Find the launch speed.

23. A 1000 kg vehicle travels at 20 m/s against a 500 N resistive force. Find power needed for constant speed and power needed at this instant for acceleration 1 m/s^2 .

24. For $U(x) = 2x^2 - 8x$ (SI units), find $F(x)$, the equilibrium position and whether equilibrium is stable.

25. A 2 kg particle has $x = t^3/3$ (SI units). Determine the net work done from $t = 0$ to 2 s using its kinetic energy.

D. Extended practice - 5 marks each

26. Derive the work-energy theorem for a variable force in one dimension. Apply it to $F = 6x$ acting on a 2 kg body from rest at $x = 0$ to $x = 2 \text{ m}$.
27. Obtain the elastic potential energy of a spring by integration. Sketch F - x and U - x graphs and explain their physical meanings.
28. Using momentum and energy conservation, derive the final velocities in a one-dimensional elastic collision. Discuss equal masses when the second body is initially stationary.
29. A small mass on a light string completes a vertical circle of radius r . Derive the minimum speeds at the top and bottom, and the corresponding string tensions.
30. Derive the speed of two bodies after a perfectly inelastic collision and the loss of kinetic energy. Evaluate for 1 kg at 6 m/s striking 2 kg at rest.

ANSWER KEY - Numerical / closed questions

2) Yes; kinetic friction on a sliding body. 8) It decreases. 9) 25 J. 10) 40 J. 11) 2.5 m/s. 12) 1 J; 20 N. 13) -12 J; mechanical-energy loss 12 J. 14) 18 J. 15) K quadruples; speed doubles. 16) Momentum 1:2; speed 2:1. 17) 10 m/s; 100 J. 18) 5 m. 19) 80 J; $4\sqrt{5} \approx 8.94 \text{ m/s}$. 20) 2 m/s; 24 J lost. 21) First stops; second moves at 5 m/s. 22) $2\sqrt{2} \approx 2.83 \text{ m/s}$. 23) 10 kW; 30 kW. 24) $F = 8 - 4x \text{ N}$; $x = 2 \text{ m}$, stable. 25) 16 J. 26) 12 J; $\text{speed}/\sqrt{12} \approx 3.464 \text{ m/s}$. 29) $\text{Top}/(gr)$, $\text{bottom}/(5gr)$; minimum-case tensions 0 and $6mg$. 30) 2 m/s; 12 J lost.