Work and Energy (Advanced)

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. A spring with spring constant 120 N/m is pulled by a force of 14.4 N. The extension is:
(a) 120 cm **(b)** 0.14 cm **(c)** 14 cm **(d)** 12 cm

2. A spring of spring constant 950 N/m is stretched by 19 cm. The elastic potential energy stored is:
(a) 17.15 J **(b)** 34.30 J **(c)** 90.25 J **(d)** 171,475 J

3. How much work is done in stretching a spring (k = 400 N/m) from an extension of 1 cm to 7 cm?
(a) 0.98 J **(b)** 0.72 J **(c)** 1.92 J **(d)** 0.96 J

4. Which of these is a conservative force?
(a) water drag on a moving boat
(b) friction between a book and a table
(c) the Earth's pull on a swinging pendulum bob
(d) friction in a machine's bearings

5. A force is conservative if the work it does:
(a) does not depend on the path taken **(b)** is always zero on any path
(c) depends on the path taken **(d)** is always negative

6. A 13 kg box is carried up 25 m by one staircase and brought down to the same spot by another. The total work done on it by gravity is: Take g = 9.8 m/s^2.
(a) −3,185 J **(b)** 3,185 J **(c)** 6,370 J **(d)** 0 J

7. A 0.5 kg block is attached to a spring (k = 200 N/m) on a smooth floor, pulled 19 cm and released. Its greatest speed is:
(a) 3.8 m/s **(b)** 38 m/s **(c)** 76 m/s **(d)** 1.9 m/s

8. Assertion (A): When a 5 kg stone falls 38 m, its gravitational potential energy decreases by 1,862 J (g = 9.8 m/s^2).
Reason (R): Gravity is a non-conservative force, so its work depends on the path.
(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.

Section B — Short answer — 8 × 2 = 16 marks

9. A force of 23.2 N stretches a spring by 29 cm. Find the spring constant.

10. Find the elastic potential energy stored in a spring of spring constant 480 N/m when it is compressed by 13 cm. (Give the answer to 2 decimal places where needed.)

11. A spring (k = 750 N/m) is already stretched by 7 cm. How much more work is needed to stretch it to 10 cm? (Give the answer to 2 decimal places where needed.)

12. Find the potential energy of a 14 kg object kept on top of a building 42 m high, taking it as zero at the base. Take g = 9.8 m/s^2.

13. A 37 kg load hangs from a wire and stretches it by 8 mm. Find the energy stored in the wire. Take g = 9.8 m/s^2. (Give the answer to 2 decimal places where needed.)

14. A uniform rod of mass 5 kg and length 3.2 m lies on the floor. How much work is needed to stand it upright on one end? Take g = 9.8 m/s^2.

15. A spring (k = 500 N/m) holds a 5 kg trolley pulled back by 18 cm on a smooth track. Find the trolley's speed as the spring returns to its natural length.

16. A 5 kg bag is moved from a shelf 27 m high to one 13 m high. Find the work done on it by gravity (with its sign). Take g = 9.8 m/s^2.

Section C — Word problems — 4 × 4 = 16 marks

17. A spring gives these readings: 2 cm for 4 N, 4 cm for 8 N, 6 cm for 12 N, 8 cm for 16 N. (a) Find the spring constant. (b) Find the work done in stretching it from 2 cm to 4 cm. (c) Find the energy stored at 8 cm. (d) A 2 kg block attached to it is released from 8 cm on a smooth floor. Find its greatest speed. (Give the answer to 2 decimal places where needed.)

18. A 1.5 kg ball is thrown straight up at 7 m/s. Ignore air resistance. Take g = 9.8 m/s^2. Find (a) its kinetic energy at launch, (b) the greatest height it reaches and (c) the height at which its kinetic energy is one-quarter of the launch value.

19. A 17 kg box slides across a floor at 12 m/s and stops after 3 m because of friction. Find (a) its kinetic energy at the start, (b) the work done on it by friction (with its sign) and (c) the friction force. (d) Is friction conservative? (Yes or No) (Give the answer to 2 decimal places where needed.)

20. A 10 kg mass is hung gently from a spring (k = 392 N/m) and comes to rest. Take g = 9.8 m/s^2. Find (a) the extension in metres, (b) the energy stored in the spring, (c) the loss of gravitational potential energy of the mass and (d) the loss of potential energy is how many times the energy stored in the spring? (Give the answer to 2 decimal places where needed.)

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Answer key

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Q	Answer	Working
1	**(d) 12 cm**	$x = F \div k = 14.4 \div 120 = 0.12$ m
2	**(a) 17.15 J**	$U = \frac{1}{2}kx^2 = \frac{1}{2} \times 950 \times (0.19)^2$
3	**(d) 0.96 J**	$W = \frac{1}{2}k(x_2^2 - x_1^2) = \frac{1}{2} \times 400 \times (0.07^2 - 0.01^2)$
4	**(c) the Earth's pull on a swinging pendulum bob**	gravity and spring forces do work that does not depend on the path
5	**(a) does not depend on the path taken**	only the start and end points matter
6	**(d) 0 J**	gravity is conservative: over a closed path its work is 3,185 − 3,185 = 0
7	**(a) 3.8 m/s**	$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$, so $v = x\sqrt{(k/m)} = 0.19 \times \sqrt{400}$
8	**(c) A is true, but R is false.**	A is true: mgh = 5 × 9.8 × 38 = 1,862. R is false.
9	**80 N/m**	$k = F \div x = 23.2 \div 0.29$
10	**4.06 J**	$\frac{1}{2}kx^2 = \frac{1}{2} \times 480 \times 0.13^2$
11	**1.91 J**	area under the F–x graph = $\frac{1}{2}k(x_2^2 - x_1^2)$
12	**5,762.4 J**	mgh = 14 × 9.8 × 42
13	**1.45 J**	energy = ½ × force × extension = ½ × 362.6 × 0.008
14	**78.4 J**	its centre rises by L/2 = 1.6 m: W = mg × L/2
15	**1.8 m/s**	$\frac{1}{2} \times 500 \times 0.18^2 = \frac{1}{2} \times 5 \times v^2$
16	**W = 686 J**	$W = -\Delta U = mg(h_1 - h_2) = 5 \times 9.8 \times (27 - 13)$
17	**(a) 200 N/m; (b) 0.12 J; (c) 0.64 J; (d) 0.8 m/s**	(a) $k = F \div x$; (b) area under the graph = $\frac{1}{2}k(x_2^2 - x_1^2)$; (c) $\frac{1}{2}k(0.08)^2$; (d) $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$
18	**(a) 36.75 J; (b) 2.5 m; (c) 1.88 m**	(a) $\frac{1}{2}mu^2$; (b) $mgh = \frac{1}{2}mu^2$, $h = 7^2 \div 19.6$; (c) three-quarters of the energy is now potential: ¾ × 2.5
19	**(a) 1,224 J; (b) −1,224 J; (c) 408 N; (d) No**	(a) $\frac{1}{2} \times 17 \times 12^2$; (b) friction removes all the kinetic energy; (c) 1,224 ÷ 3; (d) the energy turns into heat and cannot be recovered
20	**(a) 0.25 m; (b) 12.25 J; (c) 24.5 J; (d) 2**	(a) $x = mg \div k$; (b) $\frac{1}{2}kx^2$; (c) mgx; (d) $mgx = kx^2$, which is twice $\frac{1}{2}kx^2$

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