



Work, Energy and Power — JEE (Main) Pattern Sample Test 2

FREE SAMPLE TEST · PHYSICS · PATTERN OF JEE (MAIN)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
60 minutes	100	25 (20 + 5)	

GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, -1 for an incorrect answer, 0 if the question is not attempted.
5. Take $g = 10 \text{ m/s}^2$ unless stated otherwise. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

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Topics covered: Work by a variable force · Work–energy theorem · Work by friction · Potential energy of a spring · Conservative and non-conservative forces · Potential energy and equilibrium · Conservation of mechanical energy · Motion in a vertical circle · Power · Collisions

SECTION A (Q1–20) · Multiple choice · +4 / 0 / –1

Each question has FOUR options. ONLY ONE of them is correct.

1. A force $F = [(2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}]$ N acts on a particle (x , y and z in m). The work done by F as the particle moves from the origin to the point (1 m, 2 m, 3 m) is

- (1) 2 J
- (2) 29 J
- (3) 31 J
- (4) Different for different paths

2. A particle of mass 2 kg is at rest at the origin at $t = 0$. From then on a force $F = (6t\hat{i} + 4\hat{j})$ N acts on it (t in s); no other force acts. The average power delivered by F in the first 2 s, and the instantaneous power at $t = 2$ s, are respectively

- (1) 52 W and 88 W
- (2) 26 W and 44 W
- (3) 26 W and 88 W
- (4) 13 W and 88 W

3. A body of mass 2 kg starts from rest on a smooth horizontal surface. The net force on it always acts along its direction of motion, and the power it delivers increases uniformly with time as $P = 4t$ (P in W, t in s). The speed of the body at $t = 3$ s and the distance it has covered by then are

- (1) $3\sqrt{2}$ m/s and $9\sqrt{2}/2$ m
- (2) 6 m/s and 9 m
- (3) $3\sqrt{2}$ m/s and $9\sqrt{2}$ m
- (4) 3 m/s and 4.5 m

4. A small block is released from rest on an incline of inclination θ . The coefficient of friction between the block and the incline increases with the distance x moved down the incline as $\mu = \alpha x$, where α is a positive constant. The distance the block covers before it stops, and its greatest speed, are

- (1) $\tan \theta/\alpha$ and $\sqrt{(g \sin \theta \tan \theta/\alpha)}$
- (2) $2 \tan \theta/\alpha$ and $\sqrt{(g \sin \theta \tan \theta/2\alpha)}$
- (3) $2 \tan \theta/\alpha$ and $\sqrt{(g \sin \theta \tan \theta/\alpha)}$
- (4) $\tan \theta/\alpha$ and $\sqrt{(2g \sin \theta \tan \theta/\alpha)}$

5. Consider the following forces acting on a particle moving in the xy-plane (k is a constant; the force in (C) is not defined at the origin).

(A) $F = k(y \hat{i} + x \hat{j})$

(B) $F = k(y \hat{i} - x \hat{j})$

(C) $F = k(x \hat{i} + y \hat{j})/(x^2 + y^2)^{3/2}$

(D) $F = k y^2 \hat{i}$

(E) $F = k(x^2 \hat{i} + y^2 \hat{j})$

Choose the correct answer from the options given below. The conservative forces are:

(1) (A), (C) and (E) only

(2) (A) and (C) only

(3) (B), (D) and (E) only

(4) (A), (B) and (C) only

6. A ball of mass 2 kg moving due east at 3 m/s collides with a ball of mass 1 kg moving due north at 4 m/s, and the two stick together. The kinetic energy lost in the collision is

(1) $25/3$ J

(2) $26/3$ J

(3) 17 J

(4) 8 J

7. A smooth sphere A moving with speed u strikes an identical smooth sphere B at rest. At the instant of impact the line joining their centres makes 60° with the velocity of A. The coefficient of restitution is $1/2$. The speeds of A and B just after the collision are

(1) $\sqrt{3}u/2$ and $3u/8$

(2) $7u/8$ and $3u/8$

(3) $7u/8$ and $u/2$

(4) $3u/4$ and $3u/8$

8. A ball of mass m moving with speed u collides head-on with a ball of mass $2m$ at rest on a smooth floor, and the first ball comes to rest. The coefficient of restitution, and the fraction of the initial kinetic energy lost, are

(1) $e = 1$; none is lost

(2) $e = 1/2$; one-quarter is lost

(3) $e = 1/4$; half is lost

(4) $e = 1/2$; half is lost

9. A small ball tied to a light inextensible string of length L is given, at the lowest point, the least horizontal speed with which it just completes the vertical circle. The height above the lowest point at which the tension in the string equals the weight of the ball is

(1) $4L/3$

(2) $3L/2$

(3) $5L/3$

(4) $7L/4$

10. A bob of mass $9m$ hangs at rest from a light inextensible string of length L . A bullet of mass m moving horizontally passes through the bob and emerges with half its initial speed. The least initial speed of the bullet for which the bob completes the vertical circle is

- (1) $9\sqrt{5gL}$
- (2) $18\sqrt{5gL}$
- (3) $10\sqrt{5gL}$
- (4) $18\sqrt{gL}$

11. A small block of mass m slides down the smooth inclined face (inclination 45°) of a wedge, also of mass m , which rests on a smooth horizontal floor. Both start from rest. When the block has descended through a height h , the work done on the block by the normal force from the wedge is

- (1) 0
- (2) $-mgh/3$
- (3) $-mgh/2$
- (4) $-mgh/6$

12. A block A of mass 1 kg is placed with a horizontal speed of 6 m/s on one end of a long plank B of mass 2 kg resting on a smooth horizontal floor. The coefficient of kinetic friction between A and B is 0.5 . Until A stops sliding on B, the work done by friction on A, the work done by friction on B, and the heat produced are respectively ($g = 10\text{ m/s}^2$)

- (1) -16 J , $+4\text{ J}$ and 12 J
- (2) -18 J , $+4\text{ J}$ and 14 J
- (3) -16 J , $+16\text{ J}$ and 0
- (4) -12 J , $+4\text{ J}$ and 8 J

13. A particle of mass m moves along the x -axis in the potential energy $U(x) = k(x^2 - a^2)^2$, where k and a are positive constants. It is released from rest at $x = 2a$. Its greatest speed in the motion that follows is

- (1) $4a^2\sqrt{k/m}$
- (2) $3a^2\sqrt{2k/m}$
- (3) $3a^2\sqrt{k/m}$
- (4) $2a^2\sqrt{2k/m}$

14. A block of mass m hangs from a light vertical spring of force constant k . It is held by hand with the spring at its natural length.

Statement I: If the hand lowers the block slowly until it hangs in equilibrium, the work done by the hand is $-m^2g^2/2k$.

Statement II: If the block is instead released suddenly from the same position, its greatest kinetic energy in the motion that follows is $m^2g^2/2k$.

In the light of the above statements, choose the correct answer from the options given below:

- (1) Both Statement I and Statement II are true
- (2) Both Statement I and Statement II are false
- (3) Statement I is true but Statement II is false
- (4) Statement I is false but Statement II is true

15. A motor raises a 50 kg load by a light rope, starting from rest. For the first 3 s the load rises with a constant acceleration of 2 m/s^2 . After that the motor keeps its power at the value reached at $t = 3 \text{ s}$. The power at $t = 3 \text{ s}$, and the greatest speed the load can reach, are respectively ($g = 10 \text{ m/s}^2$)

- (1) 3000 W and 6 m/s
- (2) 3600 W and 7.2 m/s
- (3) 3600 W and 6 m/s
- (4) 1800 W and 3.6 m/s

16. A particle of mass m moves along the x -axis under the force $F = -kx^3$, where k is a positive constant. It is released from rest at $x = A$. Its speed when it passes $x = A/2$ is

- (1) $A^2\sqrt{k/2m}$
- (2) $A^2\sqrt{15k/16m}$
- (3) $A^2\sqrt{3k/4m}$
- (4) $A^2\sqrt{15k/32m}$

17. A light rigid rod of length $2L$ is pivoted at its midpoint on a smooth horizontal axle, and carries small balls of masses m and $2m$ at its two ends. The rod is held horizontal and released from rest. The speed of the ball of mass $2m$ as it passes through its lowest position is

- (1) $\sqrt{gL}$
- (2) $\sqrt{4gL/3}$
- (3) $\sqrt{2gL/3}$
- (4) $\sqrt{2gL}$

18. A block of mass 0.5 kg on a rough horizontal floor (coefficients of static and kinetic friction both 0.2) is pressed against a light horizontal spring of force constant 200 N/m , compressing it by 10 cm , and released from rest. The block is not attached to the spring, whose other end is fixed. The greatest speed of the block, and the total distance it moves from the point of release, are ($g = 10 \text{ m/s}^2$)

- (1) 2 m/s and 1 m
- (2) 1.9 m/s and 0.9 m
- (3) 2 m/s and 0.9 m
- (4) 1.9 m/s and 1 m

19. A 2 kg block is pulled 5 m up a rough incline of inclination 37° ($\sin 37^\circ = 3/5$) at constant speed by a force parallel to the incline. The coefficient of kinetic friction is 0.5 . Match List-I with List-II.

List-I (work done, in J): (A) by gravity; (B) by friction; (C) by the pulling force; (D) by the normal reaction.

List-II: (I) 0 ; (II) -40 ; (III) $+100$; (IV) -60 .

Choose the correct answer from the options given below ($g = 10 \text{ m/s}^2$):

- (1) (A)–(II), (B)–(IV), (C)–(III), (D)–(I)
- (2) (A)–(IV), (B)–(II), (C)–(I), (D)–(III)
- (3) (A)–(III), (B)–(II), (C)–(IV), (D)–(I)
- (4) (A)–(IV), (B)–(II), (C)–(III), (D)–(I)

20. Given below are two statements.

Statement I: The total kinetic energy of a system of particles can increase even when no external force acts on the system.

Statement II: The work done by a kinetic friction force on a body is always negative.

In the light of the above statements, choose the correct answer from the options given below:

- (1) Both Statement I and Statement II are true
- (2) Both Statement I and Statement II are false
- (3) Statement I is true but Statement II is false
- (4) Statement I is false but Statement II is true

SECTION B (Q21–25) · Numerical value · +4 / 0 / –1

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

21. A pan of mass 1 kg rests on the top of a light vertical spring of force constant 100 N/m, whose lower end is fixed to the floor. A 1 kg lump of putty is dropped from a height of 30 cm above the pan, hits it and sticks to it. The greatest further compression of the spring (in cm), measured from the pan's initial position, is _____. ($g = 10 \text{ m/s}^2$)

Answer: _____

22. A bead of mass 120 g can slide on a smooth, fixed, straight horizontal wire. It is attached to a light spring of natural length 30 cm and force constant 100 N/m, whose other end is fixed at a point O in the same horizontal plane, 40 cm from the wire. The bead is released from rest at a point of the wire where the spring is 50 cm long. Its speed (in m/s) as it passes the point of the wire nearest to O is _____.

Answer: _____

23. The engine of a car of mass 1000 kg delivers a constant power, and the resistance to its motion is constant. On a level road its acceleration is 2 m/s^2 when its speed is 10 m/s and 0.5 m/s^2 when its speed is 20 m/s. Its maximum speed (in m/s) on this road is _____.

Answer: _____

24. A small ball of mass m is held just on top of a larger ball of mass $3m$, with their centres on a vertical line, and the two are dropped together from rest; the bottom of the larger ball is 1.25 m above a hard floor. The larger ball rebounds elastically from the floor and at once collides elastically and head-on with the small ball, which is still moving down. Treat the collisions as instantaneous and the balls' sizes as negligible. The height (in m) to which the small ball rises above the point of this collision is _____. ($g = 10 \text{ m/s}^2$)

Answer: _____

25. A small block starts from rest and slides without friction down a track that ends in a vertical circular loop of radius 50 cm. At the highest point of the loop, the normal force on the block from the track is twice the block's weight. The height (in cm) of the starting point above the lowest point of the loop is _____.

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(2)	(3)	(1)	(3)	(1)	(1)	(2)	(4)	(3)	(2)
Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(4)	(1)	(2)	(1)	(2)	(4)	(3)	(4)	(4)	(3)
Q21		Q22		Q23		Q24		Q25	
30		5		30		5		175	

WORKED SOLUTIONS

Q1. Answer (2). Check whether F is conservative: $\partial F_x/\partial y = 2x = \partial F_y/\partial x$, $\partial F_x/\partial z = 3z^2 = \partial F_z/\partial x$ and $\partial F_y/\partial z = 0 = \partial F_z/\partial y$, so it is. $F = \nabla\phi$ with $\phi = x^2y + xz^3$ ($\partial\phi/\partial x = 2xy + z^3$, $\partial\phi/\partial y = x^2$, $\partial\phi/\partial z = 3xz^2$). So $W = \phi(1, 2, 3) - \phi(0, 0, 0) = 1 \times 2 + 1 \times 27 = 29$ J, along any path. 2 J leaves out the z terms.

Q2. Answer (3). Integrating $a = F/m = (3t\hat{i} + 2\hat{j})$ m/s² from rest: $v = (1.5t^2\hat{i} + 2t\hat{j})$ m/s, so at $t = 2$ s, $v = (6, 4)$ m/s and $K = \frac{1}{2} \times 2 \times (36 + 16) = 52$ J = W . Average power = $W/t = 52/2 = 26$ W. At $t = 2$ s, $F = (12, 4)$ N and $P = F \cdot v = 72 + 16 = 88$ W, which is not twice the average because P grows faster than linearly. 52 W forgets to divide by the time.

Q3. Answer (1). $K = \int_0^t P dt = 2t^2$. With $m = 2$ kg, $K = v^2$, so $v = \sqrt{2}t$: at $t = 3$ s, $v = 3\sqrt{2}$ m/s. Since v grows in proportion to t , the acceleration is the constant $\sqrt{2}$ m/s², and the distance is $\frac{1}{2} \times \sqrt{2} \times 3^2 = 9\sqrt{2}/2$ m (about 6.4 m). Taking $P = 4t$ as a constant 12 W, or treating $4t$ as the force, gives the other options.

Q4. Answer (3). Work–energy theorem after a distance x : $\frac{1}{2}mv^2 = mg \sin \theta x - \int_0^x \alpha x' mg \cos \theta dx' = mg \sin \theta x - \frac{1}{2}\alpha mg \cos \theta x^2$. The block stops where this is zero again: $x = 2 \tan \theta/\alpha$. The speed is greatest where the net force is zero, $\alpha x = \tan \theta$, i.e. $x = \tan \theta/\alpha$, where $v^2 = 2g \sin \theta (\tan \theta/\alpha) - g \cos \theta \alpha (\tan \theta/\alpha)^2 = g \sin \theta \tan \theta/\alpha$. At the stopping point $\mu = 2 \tan \theta > \tan \theta$, so the block stays at rest. $\tan \theta/\alpha$ is where it is fastest, not where it stops.

Q5. Answer (1). A force in the plane is conservative when $\partial F_y/\partial x = \partial F_x/\partial y$ (on a region without holes), i.e. it is the gradient of a potential. (A) both derivatives are k : conservative (potential $-kxy$). (B) $-k \neq k$: not conservative (its work round a circle is not zero). (C) a central force whose magnitude depends only on r , k/r^2 : conservative (potential k/r). (D) $\partial F_x/\partial y = 2ky$ but $\partial F_y/\partial x = 0$: not conservative. (E) each component depends only on its own coordinate, so both cross-derivatives are 0: conservative (potential $-k(x^3 + y^3)/3$).

Q6. Answer (1). Momentum: $(6\hat{i} + 4\hat{j})$ kg m/s, carried by 3 kg, so $v^2 = (36 + 16)/9 = 52/9$ and K after = $\frac{1}{2} \times 3 \times 52/9 = 26/3$ J. K before = $\frac{1}{2} \times 2 \times 9 + \frac{1}{2} \times 1 \times 16 = 9 + 8 = 17$ J. Loss = $17 - 26/3 = 25/3$ J (about 8.3 J). 26/3 J is the kinetic energy left, not the loss.

Q7. Answer (2). The spheres are smooth, so the impulse is along the line of centres and A keeps its perpendicular component $u \sin 60^\circ = \sqrt{3}u/2$. Along the line of centres A approaches at $u \cos 60^\circ = u/2$; for equal masses, momentum and restitution give A: $(1 - e)/2 \times u/2 = u/8$ and B: $(1 + e)/2 \times u/2 = 3u/8$. Speed of A = $\sqrt{(3u^2/4 + u^2/64)} = \sqrt{(49u^2/64)} = 7u/8$; B moves at $3u/8$ along the line of centres. $\sqrt{3}u/2$ forgets A's leftover component along the line of centres.

Q8. Answer (4). Momentum: $mu = 2mV$, so $V = u/2$. $e = (\text{speed of separation})/(\text{speed of approach}) = (u/2 - 0)/u = 1/2$. K after = $\frac{1}{2}(2m)(u/2)^2 = mu^2/4$, half of $mu^2/2$, so half the kinetic energy is lost. (A ball stops on hitting a ball at rest only if e equals the mass ratio m/M ; $e = 1$ needs equal masses.)

Q9. Answer (3). Least speed at the bottom: $v_0^2 = 5gL$. At angle ϕ from the lowest point, $v^2 = 5gL - 2gL(1 - \cos \phi) = 3gL + 2gL \cos \phi$, and $T = mv^2/L + mg \cos \phi = mg(3 + 3 \cos \phi)$. $T = mg$ gives $\cos \phi = -2/3$, i.e. a height $L(1 - \cos \phi) = 5L/3$, in the upper half of the circle (the tension falls to 0 at the top).

Q10. Answer (2). Momentum during the brief passage (the string's pull is vertical): $\mu u = m(u/2) + 9mV$, so $V = u/18$. A bob on a string completes the circle if $V \geq \sqrt{5gL}$, so $u \geq 18\sqrt{5gL}$. If the bullet stayed in the bob, $\mu u = 10mV$ would give $10\sqrt{5gL}$.

Q11. Answer (4). Horizontal momentum is conserved. Let the wedge move back at V and the block move at w down the face relative to the wedge; the block's velocity is then $(w \cos 45^\circ - V)$ horizontally and $w \sin 45^\circ$ downward, and $m(w \cos 45^\circ - V) = mV$ gives $w = 2\sqrt{2} V$. Energy: $mgh = \frac{1}{2}mV^2 + \frac{1}{2}m[(w/\sqrt{2} - V)^2 + (w/\sqrt{2})^2] = \frac{1}{2}mV^2 + \frac{1}{2}m(V^2 + 4V^2) = 3mV^2$, so $V^2 = gh/3$. The normal pair does no total work (no slipping across the face), so the work it does on the block is minus the wedge's kinetic energy: $-\frac{1}{2}m(gh/3) = -mgh/6$. Zero would be true only if the wedge were fixed.

Q12. Answer (1). No horizontal external force: $1 \times 6 = 3v$, so the common speed is 2 m/s . Work on A = $\Delta K_A = \frac{1}{2} \times 1 \times (2^2 - 6^2) = -16 \text{ J}$. Work on B = $\Delta K_B = \frac{1}{2} \times 2 \times 2^2 = +4 \text{ J}$. The pair does -12 J in total, which appears as heat: 12 J (equal to $f \times$ relative sliding distance, $5 \text{ N} \times 2.4 \text{ m}$). '+16 J on B' wrongly assumes the two works cancel.

Q13. Answer (2). $U(2a) = k(3a^2)^2 = 9ka^4$. The particle has enough energy to pass over the hump at $x = 0$ ($U(0) = ka^4$), and its speed is greatest where U is least, at $x = \pm a$, where $U = 0$. $\frac{1}{2}mv^2 = 9ka^4$ gives $v = 3a^2\sqrt{2k/m}$. $4a^2\sqrt{k/m}$ is its speed at $x = 0$, the local maximum of U .

Q14. Answer (1). Statement I: the equilibrium extension is mg/k . Going slowly, the kinetic energy stays zero, so $W_{\text{hand}} + W_{\text{gravity}} + W_{\text{spring}} = 0$: $W_{\text{hand}} = -mg(mg/k) + \frac{1}{2}k(mg/k)^2 = -m^2g^2/2k$. True. Statement II: released suddenly, the block is fastest at the equilibrium position, where $K = mg(mg/k) - \frac{1}{2}k(mg/k)^2 = m^2g^2/2k$ (it oscillates down to $2mg/k$). True.

Q15. Answer (2). Tension $T = m(g + a) = 50 \times 12 = 600 \text{ N}$, speed at $3 \text{ s} = 6 \text{ m/s}$, so $P = Tv = 3600 \text{ W}$. With the power held at 3600 W the load keeps speeding up ($T = P/v$ is still more than mg) until $P/v = mg$: $v_{\text{max}} = 3600/500 = 7.2 \text{ m/s}$. 6 m/s is only the speed at $t = 3 \text{ s}$; 1800 W is the average power over the first 3 s .

Q16. Answer (4). $U(x) = -\int F dx = kx^4/4$. Energy: $\frac{1}{2}mv^2 = k(A^4 - A^4/16)/4 = 15kA^4/64$, so $v^2 = 15kA^4/32m$ and $v = A^2\sqrt{15k/32m}$. $A^2\sqrt{15k/16m}$ drops the $\frac{1}{2}$ in the kinetic energy.

Q17. Answer (3). Both balls move on circles of radius L with the same speed v . When the rod is vertical, $2m$ has fallen L and m has risen L , so the loss of potential energy is $2mgL - mgL = mgL = \frac{1}{2}(m + 2m)v^2$, which gives $v = \sqrt{(2gL/3)}$. $\sqrt{(4gL/3)}$ forgets that the lighter ball rises; $\sqrt{(2gL)}$ treats $2m$ as falling freely.

Q18. Answer (4). Friction is $\mu mg = 1 \text{ N}$. The spring force (20 N at first) overcomes it, and the speed is greatest where $kx = 1 \text{ N}$, i.e. at a compression of 0.5 cm , not at the natural length: $\frac{1}{2}mv^2 = \frac{1}{2} \times 200 \times (0.10^2 - 0.005^2) - 1 \times 0.095 = 0.9975 - 0.095 = 0.9025 \text{ J}$, so $v^2 = 3.61$ and $v = 1.9 \text{ m/s}$. All the spring's 1 J of energy is eventually used against friction, $1 \text{ N} \times d$, so $d = 1 \text{ m}$ (it leaves the spring at the natural length still moving). 2 m/s ignores friction while the spring is pushing.

Q19. Answer (4). Gravity: $-mg \sin 37^\circ \times 5 = -12 \times 5 = -60 \text{ J}$. Friction: $-\mu mg \cos 37^\circ \times 5 = -8 \times 5 = -40 \text{ J}$. The speed is constant, so the net work is zero and the pull does $+100 \text{ J}$. The normal reaction is perpendicular to the motion: 0 . So (A)–(IV), (B)–(II), (C)–(III), (D)–(I).

Q20. Answer (3). Statement I is true: internal forces can do net work, e.g. two blocks pushed apart by a compressed spring between them, or an exploding shell; momentum is conserved but kinetic energy grows. Statement II is false: a block placed on a moving plank (or a conveyor belt) is dragged forward by kinetic friction while it slips, and that friction does positive work on it; only the total work of the friction pair is negative.

Q21. Answer 30. The putty hits the pan at $\sqrt{(2 \times 10 \times 0.3)} = \sqrt{6} \text{ m/s}$; sticking (momentum) gives $v = \sqrt{6}/2 \text{ m/s}$, so the kinetic energy of the 2 kg is $\frac{1}{2} \times 2 \times 1.5 = 1.5 \text{ J}$. The spring is already compressed by $x_0 = 10/100 = 0.1 \text{ m}$. For a further compression x : $1.5 + 20x = \frac{1}{2} \times 100[(0.1 + x)^2 - 0.1^2] = 10x + 50x^2$, so $50x^2 - 10x - 1.5 = 0$ and $x = (10 + 20)/100 = 0.3 \text{ m} = 30 \text{ cm}$. Keeping the putty's full kinetic energy (no loss in the collision) would give more.

Q22. Answer 5. Only the spring does work on the bead along the wire (the wire's normal force is perpendicular to it). Extension at release: $50 - 30 = 20 \text{ cm}$; at the nearest point the spring is 40 cm long, extension 10 cm . $\frac{1}{2} \times 0.12 \times v^2 = \frac{1}{2} \times 100 \times (0.2^2 - 0.1^2) = 1.5 \text{ J}$, so $v^2 = 25$ and $v = 5 \text{ m/s}$.

Q23. Answer 30. Driving force P/v . $P/10 - R = 1000 \times 2$ and $P/20 - R = 1000 \times 0.5$. Subtracting, $P/20 = 1500$, so $P = 30 \text{ kW}$ and $R = 1000 \text{ N}$. At maximum speed $P/v = R$: $v = 30000/1000 = 30 \text{ m/s}$.

Q24. Answer 5. Both reach the floor at $\sqrt{2 \times 10 \times 1.25} = 5 \text{ m/s}$. The large ball rebounds at 5 m/s up and meets the small ball moving at 5 m/s down. Taking up as positive, for an elastic collision the small ball leaves with $v = [(m - 3m)(-5) + 2(3m)(5)]/(4m) = (10 + 30)/4 = 10 \text{ m/s}$ up (and the large ball is left at rest). It rises $v^2/2g = 100/20 = 5 \text{ m}$.

Q25. Answer 175. At the top, $N + mg = mv^2/R$ with $N = 2mg$, so $v^2 = 3gR$. Energy from the start (height H) to the top (height $2R$): $v^2 = 2g(H - 2R) = 3gR$, so $H = 3.5R = 175 \text{ cm}$. $N = 0$ at the top would give $2.5R = 125 \text{ cm}$, the least height for the block to go round.

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