Work and Energy

1. A boy of mass 50 kg runs up a flight of 120 stairs, each measuring a height of 25 cm, in one minute and 40 seconds. If $g = 10\ m\ s^{-2}$, the power of the boy is

(a) 150 W (b) 750 W
(c) 500 W (d) 250 W

2. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional forces are 10% of energy. How much power is generated by the turbine? $(g = 10\ m/s^2)$

(a) 12.3 kW (b) 7.0 kW
(c) 8.1 kW (d) 10.2 kW

3. A body of mass 2 kg is thrown up vertically with a kinetic energy of 490 J. If the acceleration due to gravity is $9.8\ m\ s^{-2}$, the height at which the kinetic energy of the body becomes half of the original value is

(a) 50 m (b) 25 m
(c) 12.5 m (d) 10 m.

4. Read the given statements and select the correct option.

Statement 1: If a light body and a heavy body possess the same momentum, the lighter body will possess more kinetic energy.

Statement 2: The kinetic energy of a body varies as the square of its velocity.

(a) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.
(b) Both statements 1 and 2 are true but statement 2 is not the correct explanation of statement 1.
(c) Statement 1 is true but statement 2 is false.
(d) Both statements 1 and 2 are false.

5. Coolie A takes 1 min to raise a box of mass m through a height of 2.0 m. Another coolie 6 takes 30 s for the same job. Which one has greater power?

(a) Coolie A
(b) Coolie B
(c) Both have the same power
(d) Cannot say

6. Read the given statements and select the correct option.

Statement 1: A man carrying a bucket of water and walking on a rough level road with a uniform velocity does no work while carrying the bucket.

Statement 2: The work done on a body by a force (F) in giving it a displacement (S) is defined as $W = \vec{F} \cdot \vec{S} = FS\ \cos\theta$, where θ is the angle between vectors $\vec{F}$ and $\vec{S}$.

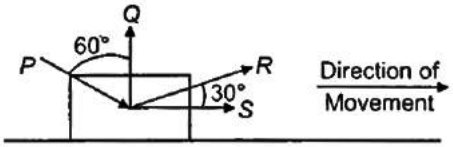
(a) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.
(b) Both statements 1 and 2 are true but statement 2 is not the correct explanation of statement 1.
(c) Statement 1 is true but statement 2 is false.
(d) Both statements 1 and 2 are false.

7. Match the columns and select the correct option from the codes given below.

Column I	Column II
(A) Work done by all the forces	(i) Change in potential energy
(B) Work done by conservative forces	(ii) Change in kinetic energy
(C) Work done by external forces	(iii) change in mechanical energy
(D) Work done in uniform velocity	(iv) Zero

(a) (A) - (ii), (B) - (i), (C) - (iii), (D) - (iv)
(b) (A) - (i), (B) - (iii), (C) - (iv), (D) - (ii)
(c) (A) - (iii), (B) - (iv), (C) - (ii), (D) - (i)
(d) (A) - (iv),(B) - (ii), (C) - (i), (D) - (iii)

8. Four forces of equal magnitude are acting on an object as shown in figure. Which of the following forces does the least work?



(a) P (b) Q
(c) R (d) S

9. A truck and a car having equal kinetic energies are stopped by applying equal retarding force. If

S_1 and S_2 are the distances covered by truck and car respectively, before stopping, then

(a) $S_1 = S_2$ (b) $S_1 > S_2$

(c) $S_1 < S_2$ (d) Cannot say

10. A particle of mass M_1 is moving with a velocity v_1, and another particle of mass M_2, is moving with a velocity v_2. Both of them have the same momentum but their different kinetic energies are E_1 and E_2 respectively. If mass M_1 is greater than mass M_2 then

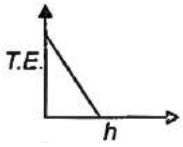
(a) E_1 is greater than E_2

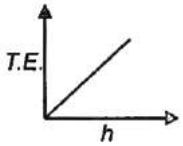
(b) E_1 is less than E_2

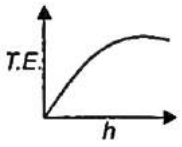
(c) E_1 is equal to E_2

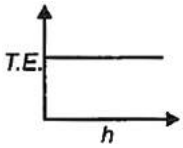
(d) Ratio of E_1 and E_2 is equal to ratio of M_1 and M_2

11. A graph of the total energy of a freely falling body from a height is

(a) 

(b) 

(c) 

(d) 

12. Read the given statements and select the correct option.

Statement 1: If a rocket explodes in mid-air, its kinetic energy increases.

Statement 2: Chemical energy of the fuel provides additional kinetic energy to the fragments.

(a) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.

(b) Both statements 1 and 2 are true but statement 2 is not the correct explanation of statement 1.

(c) Statement 1 is true but statement 2 is false.

(d) Both statements 1 and 2 are false.

13. Consider the following statements and select the correct option which identifies true (T) and false (F).

(i) When a body thrown up, its kinetic energy gradually changes into potential energy.

(ii) When a body falls from a certain height, its potential energy remains the same.

(iii) If two unequal masses have the same momentum, then the heavier body possesses lesser kinetic energy.

	(i)	(ii)	(iii)
(a)	T	F	T
(b)	F	T	F
(c)	T	T	F
(d)	F	F	T

14. Potential energy of an object at a height h is $E_p = mgh$. This equation is true only if

(i) The acceleration due to gravity is constant.

(ii) The potential energy is path dependent.

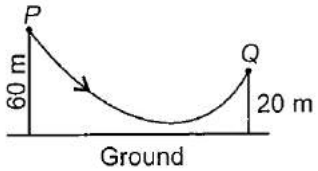
(a) Only (i) is true.

(b) Only (ii) is true.

(c) Both (i) and (ii) are false

(d) Both (i) and (ii) are true.

15. A skier of mass 50 kg stands at point P at the top of the ski jump and moves from P to Q and takes off his jump at Q as shown in figure. If 50% of the change in the gravitational potential energy of the skier between points P and Q becomes the kinetic energy at Q then the speed at which the skier arrives at Q is



(a) 10 m s^{-1} (b) 20 m s^{-1}

(c) 30 m s^{-1} (d) 40 m s^{-1}

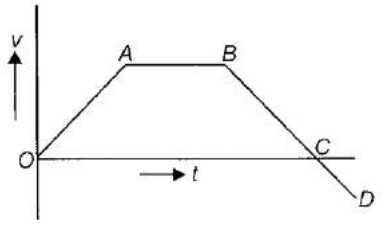
Achievers Section (HOTS)

16. A mass of *M* kg is suspended by a weightless string. The horizontal force that is required to displace it until the string making an angle of $45°$ with the initial vertical direction is

(a) $Mg(\sqrt{2}-1)$ (b) $Mg(\sqrt{2}+1)$

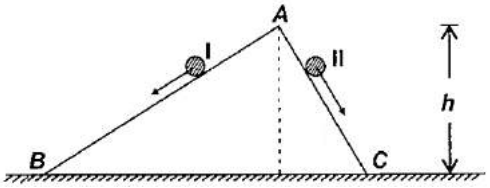
(c) $Mg\sqrt{2}$ (d) $\frac{Mg}{\sqrt{2}}$

17. A body moves under a variable force. For the body a plot of velocity versus time is shown in figure. The correct statement is



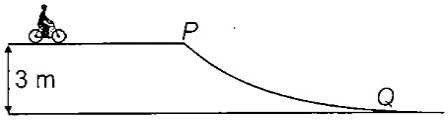
(a) In moving from C to D, work done by the force on the body is positive
(b) In moving from B to C, work done by the force on the body is positive
(c) In moving from A to B, the body does work on the system
(d) In moving from O to A, work done by the body and is negative.

18. Two inclined frictionless tracks, one gradual and the other steep meet at point A from where two stones (I and II) are allowed to slide down from rest, one on each track as shown in figure. Which of the following statements is correct?



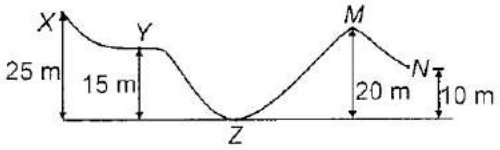
(a) Both the stones reach the bottom at the same time but not with the same speed.
(b) Both the stones reach the bottom with the same speed and stone I reaches the bottom earlier than stone II.
(c) Both the stones reach the bottom with the same speed and stone II reaches the bottom earlier than stone I.
(d) Both the stones reach the bottom at different times and with different speeds.

19. The diagram shows a cyclist moving down a small hill at P before travelling on a flat road at Q. The total mass of the cyclist and his bicycle is 60 kg and the speed of the cyclist at P is $10\ ms^{-1}$. Which of the following is incorrect?



(a) The kinetic energy at P is 3000 J.
(b) The loss of gravitational energy between P and Q is 1800 J.
(c) Total energy is 4800 J.
(d) The cyclist does not require a greater power when he travels at a higher constant speed.

20. The diagram shows an object released from point X and travelling on a frictionless track. If a heavier object is taken in consideration then



(i) It will move with a greater speed at Y.
(ii) The speed of the object at M is $10\ ms^{-1}$.

(a) Only (i) is true.
(b) Only (ii) is true.
(c) Both (i) and (ii) are true.
(d) Neither (i) nor (ii) is true.

Answer key

1. A	**2.** C	**3.** C	**4.** B	**5.** B
6. B	**7.** A	**8.** B	**9.** A	**10.** B
11. D	**12.** B	**13.** A	**14.** A	**15.** B
16. A	**17.** A	**18.** C	**19.** D	**20.** B

HINTS & EXPLANATIONS

1. (a) : Here, mass, m = 50 kg
Height of the staircase,

$$h = 120 \times \frac{25}{100} = 30m$$

Time taken to climb $= 1 \text{ min } 40 \text{ sec} = 100 \text{ s}$

We know, Power, $P = \frac{\text{Work done}}{\text{Time taken}} = \frac{mgh}{t}$

$$= \frac{50 \times 10 \times 30}{100} = 150W$$

2. (c) : Mass of water falling/second = 15 kg/s
h = 60 m, g = 10 m/s^2, loss = 10%
i.e., 90% is used.
Power generated $= 15 \times 10 \times 60 \times 0.9$
$= 8100 \text{ W} = 8.1 \text{ kW}.$

3. (c) : We know, if a body is thrown up vertically its KE goes on decreasing and PE goes on increasing. There is conversion of KE into PE. When kinetic energy becomes half of original value, the other half is converted into potential energy.

Therefore, $\frac{490}{2} = 2 \times 9.8 \times h$

Or $h = \frac{490}{2 \times 2 \times 9.8}$ or $h = 12.5m$

Thus, the required height is $12.5m$

4. (b) : Relation between momentum and KE(E_K) is

$$p = \sqrt{2mE_k}$$

If mass of body decreases then KE should increase accordingly to maintain constant momentum.

Also, $E_K = \frac{1}{2}mv^2$ or $E_K \propto v^2$

5. (b) : $\text{Power} = \frac{\text{Work}}{\text{time}}$
$\therefore$ Work done by both of them is same.
Hence, coolie who have taken less time has greater power i.e., coolie B.

6. (b) : While carrying a bucket, angle between vectors F and S becomes $90°$.
So, $W = \vec{F} \cdot \vec{S} = FS \cos\theta = FS \cos 90° = 0.$
Hence, work done is zero.

7. (a) Not Available

8. (b) : There is no work done when the force and the displacement are perpendicular to each other. The maximum work is done when the force applied is parallel to the direction of movement.

9. (a) : Let m_1, m_2 be the masses and u_1, u_2 be the initial velocities of the truck and car respectively. As KE of both are equal,

So, $\frac{1}{2}m_1u_1^2 = \frac{1}{2}m_2u_2^2$ or $\frac{m_1}{m_2} = \frac{u_2^2}{u_1^2}$ …(i)

As equal retarding force is applied on both then

$$0 = u_1^2 - \frac{2fS_1}{m_1} \Rightarrow S_1 = \frac{m_1u_1^2}{2f}$$

And $0 = u_2^2 - \frac{2fS_2}{m_2} \Rightarrow S_2 = \frac{m_2u_2^2}{2f}$

So, $\frac{S_1}{S_2} = \frac{m_1u_1^2}{m_2u_2^2} \therefore \frac{S_1}{S_2} = \frac{1}{1}$ or $S_1 = S_2$

10. (b) : $E = \frac{p^2}{2m}$ if p=constant then $E \propto \frac{1}{M}$
As $M_1 > M_2 \therefore E_1 < E_2$

11. (d) : Total energy remains constant.

12. (b) Not Available

13. (a) : When a body falls from a certain height its potential energy gradually changes into kinetic energy.

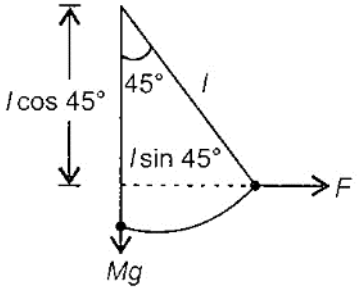
14. (a) Not Available

15. (b) : Change in gravitational potential energy of the skier $E_P = mgh = 50 \times 10 \times [60 - 20]$
$= 20000J = 2 \times 10^4 J$
Kinetic energy, $E_K = 50\%$ of

$$E_P = \frac{1}{2} \times 2 \times 10^4 J = 1 \times 10^4 J$$

$$E_K = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2E_K}{m}} = \sqrt{\frac{2 \times 1 \times 10^4}{50}} = 20ms^{-1}$$

16. (a) :Work done in displacement is equal to gain in potential energy of mass



Work done $= F \times l \sin 45° = \frac{Fl}{\sqrt{2}}$

Gain in potential energy $= Mg(l - l\cos 45°)$

$= Mgl\left(1 - \frac{1}{\sqrt{2}}\right) \therefore \frac{Fl}{\sqrt{2}} = \frac{Mgl(\sqrt{2}-1)}{\sqrt{2}}$

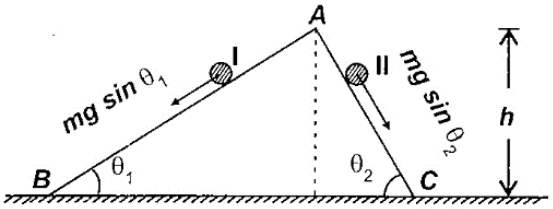
Or $F = Mg(\sqrt{2}-1)$

17. (a) : In moving from C to D, slope of graph is negative which means acceleration (force) is negative and displacement is also negative as the area under curve CD lies below the time axis. Hence, work done by the force on the body is positive.

18. (c) :AB and AC are two smooth planes inclined to the horizontal at different angles.
As height of both the planes are same, therefore, both the stones will reach the bottom with same speed.

$\because v = \sqrt{2gh}$

$\therefore v_1 = v_2$



From figure,

acceleration, $a_1 = g \sin \theta_1$

acceleration, $a_2 = g \sin \theta_2$

As $\theta_2 > \theta_1$, so $a_2 > a_1$

Using, $v = u + at$

$v_1 = u_1 + a_1 t_1; v_1 = a_1 t_1$

$t_1 = \frac{V_1}{a_1}$

Similarly, $t_2 = \frac{V_2}{a_2} \because a_2 > a_1$

So, $t_2 < t_1$

Hence, stone II takes less time to reach the bottom.

19. (d) :(a) $K = \frac{1}{2} \times 60 \times 10 \times 10 = 3000J$

(b) $\text{PE} = 60 \times 10 \times 3 = 1800$ J

(c) Total energy = KE + Loss of gravitational potential energy = 3000 + 1800 = 4800 J

(d) The air resistance is higher when he travels at a higher constant speed, so a higher rate of work is done against air resistance.

$\therefore$ Higher power is required.

20. (b) : The speed of the object is affected by the height from which it is released.

$mgh = \frac{1}{2}mv^2$

$v = \sqrt{2gh}$ or $v \propto \sqrt{h}$

No, heavier object will not move with a greater speed at Y.

Speed of the object at M

Loss in PE = KE

$mg(25-20) = \frac{1}{2}mv^2 \therefore v^2 = 100$

Or $v = 10 ms^{-1}$