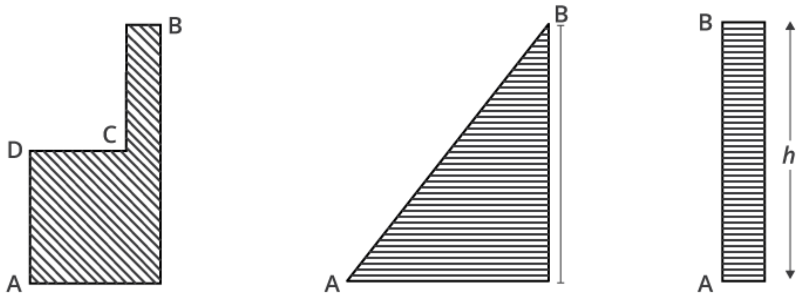
QUIZ: WORK & ENERGY-II

POTENTIAL ENERGY

1. Consider the following figures.

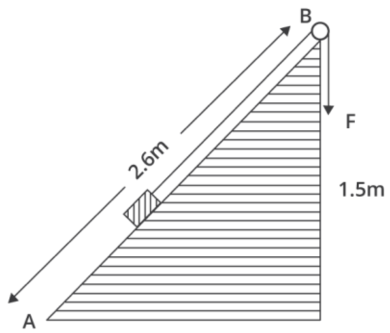


(i) (ii) (iii)

Fig (i): A ball is taken from point A to D, D to C and C to B and is placed at B.
Fig (ii): An identical second ball is taken from A to B along the slope AB and placed at B.
Fig (iii): A third identical ball is taken vertically up from A to B and placed at B.

Let P(i) represent potential energy of ball B in Fig (i), and similarly P(ii) and P(iii) represent potential energy of ball at B in Fig (ii) and Fig (iii) respectively. Which of the following relations is true about potential energy of the ball at B in three cases?
(a) P(i) > P(ii) > P(iii)
(b) P(ii) > P(iii) > P(i)
(c) P(iii) > P(ii) > P(i)
(d) P(i) = P(ii) = P(iii)

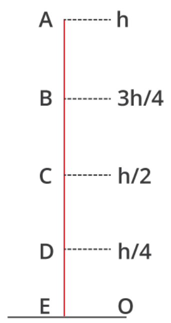
2. An object of 200g is moved from point A to point B, using the arrangement shown in the figure. The work done in moving the object from A to B (take g =9.8 m/s^2).



(a) 2.94 J
(b) 5.09 J
(c) 25.48 J
(d) 50.96 J

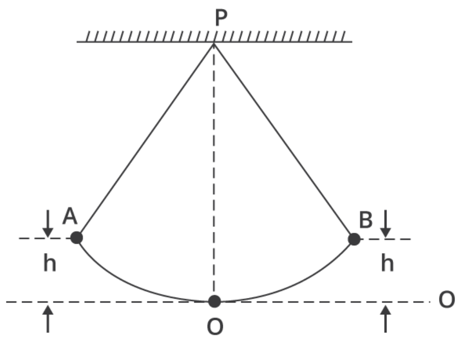
LAW OF CONSERVATION OF ENERGY

3. Points A, B, C and D are located at a height h, 3h/4, h/2 and h/4 with respect to ground respectively as shown in figure. A ball is dropped from A and reaches E. At which points of its path, the potential energy (P.E.) of the ball is three times its kinetic energy (K.E.)? Neglect air resistance.



(a) A
(b) B
(c) C
(d) D

4. Figure shows a simple pendulum, suspended from point P. The pendulum is set in motion. The bob oscillates between positions A and B, through position O. As shown in the figure, the bob is raised through height h, at extreme positions A and B, with respect to position O.
Let U, K and E be respectively the potential energy, kinetic energy and total energy of the pendulum at any point on its path.
Which of the following is correct about U and K at A or B?



(a) U = 0, K = E
(b) U = E, K = 0
(c) U = K = E/2
(d) U = 3E/4, K = E/4

RATE OF DOING WORK: POWER

5. A dam is constructed on a large river to generate hydroelectric power. 1.55×10^7 kg of water falls per second through a height of 260m in this dam. If half of the potential energy of water is converted into electric power, the power generated is (take g = 9.8 m/s^2)
(a) 19.747 MW
(b) 39.494 MW
(c) 19747 MW
(d) 39494 MW

6. Renuka visits a historical monument. To reach the monument, one has to climb 65 stairs. The height of each stair is 22 cm. She runs up and reaches the monument in 25s. Her mass is 50 kg. The power generated by her during running up is (take g = 9.8 m/s^2)
(a) 14 W

(b) 28 W
(c) 140 W
(d) 280 W

Answers:

1. (d)
Options:
(a) Point B is at the same height in Fig (i) as in other figures. Therefore P(i) = P(ii) =P(iii). Hence this option is wrong.
(b) It is the height of point B relative to points A that matters for the potential energy and not the length of path taken to reach that height. Hence this option is wrong.
(c) Since height between point A and B is same in all three figures. Therefore P(i) = P(ii) = P(iii).
Hence this option is wrong.
(d) Since B is at the same position with respect to A in all three figures. Therefore P(i) = P(ii) = P(iii). Hence this option is correct.
Explanation: Potential energy of an object depends on the final position of the object with respect to initial position. Point B is at the same height with respect to point A in all three figures. Hence P (i) = P (ii) =P (iii).

2. (a)
Options:
(a) Work done = mgh = 0.2 × 9.8× 1.5 = 2.94J. The height taken is the vertical height. Hence this option is correct.
(b) Height taken is 2.6 m which is not the correct value of h and would give w= 5.09J. Hence this option is wrong.
(c) This is the product of g (9.8 m/s^2) with distance AB (2.6m). But since work done = mgh, and h is 1.5m and not 2.6m and mass is 0.2kg and not 1kg. Hence this option is wrong.
(d) This is the product of g (9.8m/s^2) with distance AB (2.6m) and mass (2kg). But since work done = mgh and height is 1.5m and not 2.6m. Mass is 0.2kg and not 2kg. Hence this option is wrong.
Explanation: The work done in moving the object from A to B is stored as potential energy of the object at B. Therefore work done = mgh = 0.2 kg × 9.8 m/s^2 × 1.5 m = 2.94 J.

3. (b)
Options:

(a) At point A, P.E. = *mgh*, K.E. = 0
Hence this option is wrong.

(b) At point B, P.E. = $mg\frac{3h}{4}$. K.E. = Loss in P.E = *mg (h/4).*Therefore

$\frac{P.E}{K.E}$ = 3. Hence this option is correct.

(c) Point C is the mid-point of AB. Hence P.E. = K.E.= $\frac{mgh}{2}$

So ratio is 1. Hence this option is wrong.

(d) At point D, P.E. = $\frac{mgh}{4}$, K.E. = $\frac{mg3h}{4}$

P.E/K.E = $\frac{1}{3}$, Hence this option is not correct.

Explanation: The potential energy of the ball at point A is *mgh*. As the ball moves down, part of potential energy gets converted into K.E. At point E, the whole potential energy is converted into K. E. At point B, P.E. = mg (3h/4). The loss in P.E. (=mgh/4) is converted into K.E. So P.E. is three times the K.E at point B.

NOTE FOR TEACHERS:

This context can be used to generate other questions. To make it easier, one can ask about the point at which potential and kinetic energy are equal. Or one can ask about the point where potential energy is completely converted into kinetic energy (Point E). A third question may include the point where kinetic energy is three time the potential energy (Point D).

4. (b)

Options:

(a) Applying conservation of energy principle, kinetic energy at A or B is zero i.e K=0 thus total energy *U*= *mgh* = E. Hence this option is wrong.

(b) Applying conservation of energy principle, kinetic energy at A or B is zero thus total energy equals to potential energy since E=U+K i.e. U = *mgh* = E, and K = 0. Hence this option is correct.

(c) Applying conservation of energy principle, kinetic energy of bob at A or B = 0. Hence this option is wrong.

(d) Applying conservation of energy principle, kinetic energy of bob at A or B = 0. Hence this option is wrong.

Explanation: The pendulum is in motion under force of gravity. Hence Law of conservation of energy is applicable, neglecting air resistance. E is constant. At B or A, the pendulum has risen to a height h and it is momentarily at rest and hence K = 0, U = E. When it moves to point

O, total energy E is converted into kinetic energy, giving the bob maximum speed. So at O, K = E, U = zero. Note that height is measured with respect to point O.

NOTE FOR TEACHERS: This context can be used to generate other questions. One can ask about U and K at point O. Or to investigate more into it, one can ask U and K at a point where bob has been raised by h/2 or h/4 or 3h/4.

5. (c)

Options:

(a) Power generated = $\frac{1}{2} \times$ P.E of water

$= \frac{1}{2} \times 1.55 \times 10^7 \times 9.8 \times 260$

= 19747 MW

Hence this option is wrong.

(b) Power generated = $\frac{1}{2} \times$ P.E of water

$= \frac{1}{2} \times 1.55 \times 10^7 \times 9.8 \times 260$

= 19747 MW

Hence this option is wrong.

(c) Potential energy of water = mgh = 1.55×10^7 kg $\times 9.8$ m/s$^2 \times 260$m

$= 39494 \times 10^6$ J

Only half of this potential energy is converted into electricity.

So power generated = $\frac{1}{2} \times 39494 \times 10^6$ J/s

$= 19747 \times 10^6$ W

= 19747 MW

Hence this option is correct.

(d) Power generated = $\frac{1}{2} \times$ P.E of water

$= \frac{1}{2} \times 1.55 \times 10^7 \times 9.8 \times 260$

= 19747 MW

This is twice of the correct answer. Hence this option is wrong.

Explanation: Potential energy of water = *mgh* = 1.55×10^7 kg × 9.8m × 260m = 39494×10^6 J for amount of water falling per second. Only half of this is converted into electricity. So power generated

$= \frac{1}{2} \times 39494 \times 10^6$ J/s

$= 19747 \times 10^6$ W = 19747 MW.

NOTE FOR TEACHER:

One can generate such problems using real data available on websites for dams in their regions/States or about hydroelectric dams in other countries.

6. (d)

Options:

(a) Work done = Force x distance

Power = $\frac{W}{t} = \frac{force \times distance}{time} = \frac{50 \times 9.8 \times 65 \times 0.22}{25} = 280\ W$

Hence this option is wrong

(b) Power = $\frac{W}{t} = \frac{force \times distance}{time} = \frac{50 \times 9.8 \times 65 \times 0.22}{25} = 280\ W$

Value in this option is one tenth of correct value. Hence this option is wrong.

(c) Power = $\frac{W}{t} = \frac{force \times distance}{time} = \frac{50 \times 9.8 \times 65 \times 0.22}{25} = 280\ W$

The value in this option is half of the correct value. Hence this option is wrong.

(d) Work done = Force x distance

Power = $\frac{W}{t} = \frac{force \times distance}{time} = \frac{50 \times 9.8 \times 65 \times 0.22}{25} = 280\ W$

Hence this option is correct.

Explanation: Total height = 65 × 22cm = 14.30 m.

Work done by Renuka = *mgh* = 50 kg × 9.8 m/s^2 × 14.30m

Power = Work done/time taken = 7007J/25s = 280W