PHYSICS 534

ANSWERS

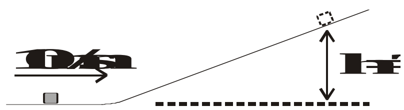
EXERCISE-40 **Potential Energy Part-2 /2**

Carl Anderson was the Nobel prize for in 1936 for his discovery the positron.

ANDERSON

➲ **Note**: **Use 10 m/s² for the acceleration due to gravity.**

1. A 2 kg mass, moving horizontally at 10 m/s, slides up a frictionless incline as illustrated in the diagram below.



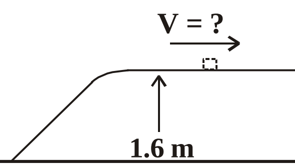
How ***high*** up the incline does the mass rise? [5 m]

$$E_K = mv^2/2 = (2\,kg)(10\,m/s)/2 = 100\,J$$

$$E_P = E_K = mgh$$

$$\therefore \quad h = \frac{E_K}{mg} = \frac{100\,J}{(2\,kg)(10\,m/s^2)} = 5\,m$$

2. A 2 kg mass, moving at 10 m/s, slides up an incline whose height is 1.6 m (see diagram). Assuming the system is frictionless, what is the velocity of the mass at the top of the incline? [8.2 m/s]



$$E_K = mv^2/2 = (2\,kg)(10\,m/s)^2 = 100\,J$$

$$E_P = mgh = (2\,kg)(10\,m/s^2)(1.6\,m) = 32\,J$$

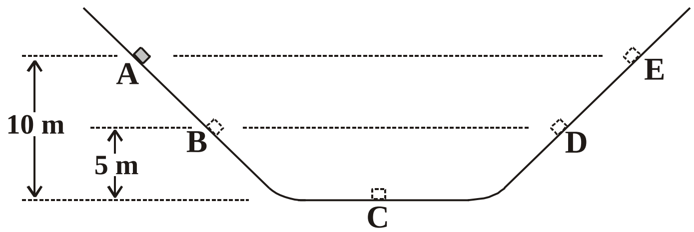
$$E_{K\,at\,top} = E_{K\,at\,bottom} - E_{P\,at\,top} = 100\,J - 32\,J = 68\,J$$

$$\text{But} \quad E_K = mv^2/2$$

$$\text{Or} \qquad v^2 = \frac{2E_K}{m}$$

$$\therefore \qquad v = \sqrt{\frac{2E_K}{m}} = \sqrt{\frac{2(68\,J)}{2\,kg}} = 8.2\,m/s$$

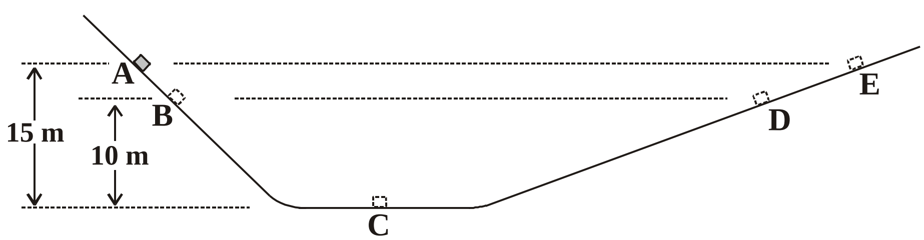
3. Starting from rest, a 1 kg mass slides down a frictionless shoot as illustrated in the following diagram.



Fill-in the table below with the potential, kinetic and total energy of the block at the points A, B, C, D and E along the shoot.

POINT	Potential Energy (E_P)	Kinetic Energy (E_K)	Total Energy
A	100 J	0	100 J
B	50 J	50 J	100 J
C	0	100 J	100 J
D	50 J	50 J	100 J
E	100 J	0	100 J

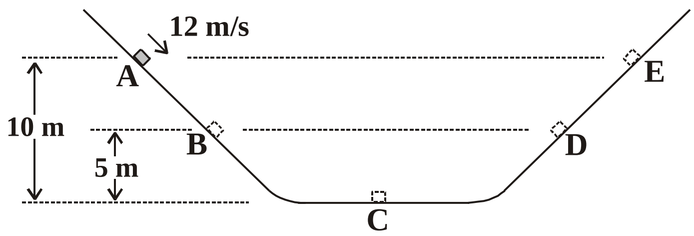
4. Starting from rest, a small block of mass 1 kg slides down a frictionless shoot as illustrated in the following diagram.



Fill-in the table below with the potential, kinetic and total energy of the block at the points A, B, C, D and E along the shoot.

POINT	Potential Energy (E_P)	Kinetic Energy (E_K)	Total Energy
A	150 J	0	150 J
B	100 J	50 J	150 J
C	o	150 J	150 J
D	100 J	50 J	150 J
E	150 J	150 J	150 J

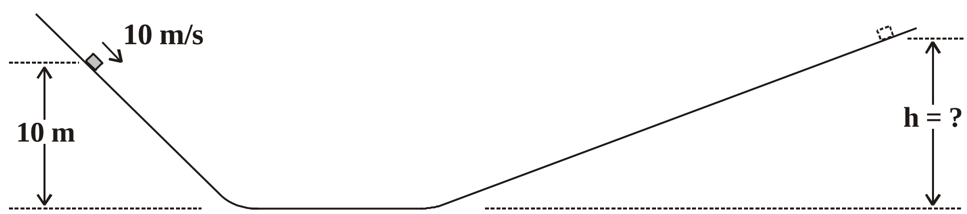
5. Starting with an initial velocity of 12 m/s, a 1 kg object slides down a frictionless shoot as illustrated in the following diagram.



Fill-in the table below with the potential, kinetic and total energy of the block at the points A, B, C, D and E along the shoot.

POINT	Potential Energy (E_P)	Kinetic Energy (E_K)	Total Energy
A	100 J	72 J	172 J
B	50 J	122 J	172 J
C	0	172 J	172 J
D	50 J	122 J	172 J
E	100 J	72 J	172 J

6. Starting with an initial velocity of 10 m/s, a 2 kg object slides down a frictionless shoot as illustrated in the following diagram. [15 m]



How ***high*** up the incline does the mass travel before coming to a stop? [15 m]

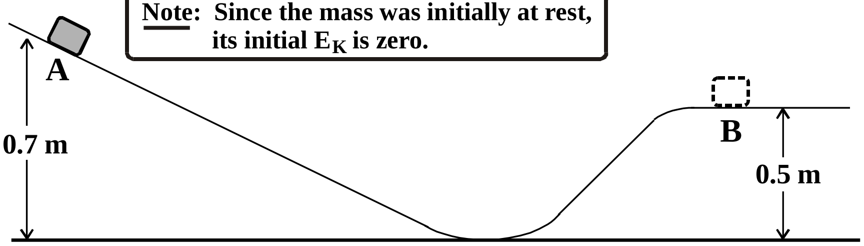
$$E_K = mv^2/2 = (2\,kg)(10\,m/s)^2/2 = 100\,J$$
$$E_P = mgh = (2\,kg)(10\,m/s^2)(10\,m) = 200\,J$$
$$E_T = E_K + E_P = 100\,J + 200\,J = 300\,J$$
$$\because \quad E_P = mgh$$
$$\therefore \quad h = \frac{E_P}{mg} = \frac{300\,J}{(2\,kg)(10\,m/s^2)} = 15\,m$$

7. Starting from rest, a mass is released on a frictionless track as illustrated in the diagram below. Describe the motion of the mass.

The motion of the mass is similar to the swings of a pendulum. Because the system is frictionless (an ideal case where there is no loss of energy), the total energy of the mass at its starting point consists only of potential energy. At its lowest point, the total energy of the mass consists only of kinetic energy. Since there is no energy loss, the mass goes back up to its original height on the right hand side. This cycle then repeats itself indefinitely.

8. A 5 kg mass, initially at rest, is released from point-A and slides down a frictionless ramp as illustrated in the diagram below. What is the velocity of the mass at point-B? [2 m/s]

Note: Since the mass was initially at rest, its initial E_K is zero.



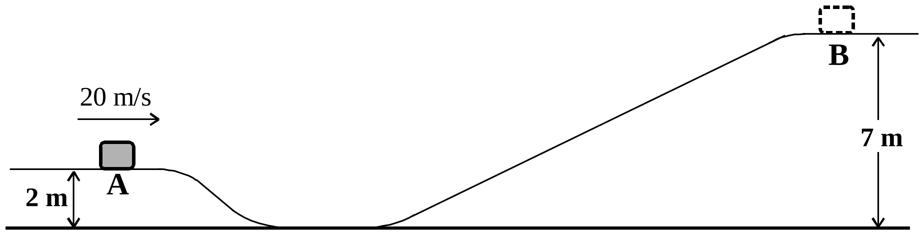
$$E_T \text{ at point–A}: \quad E_T = E_P + E_K = mgh + 0 = (5\text{ kg})(10\text{ m/s}^2)(0.7\text{ m}) = 35\text{ J}$$

$$E_T \text{ at point–B}: \quad E_T = E_P + E_K$$

$$\therefore\ E_K = E_T - E_P = E_T - mgh = 35\text{ J} - mgh = 35\text{ J} - (5\text{ kg})(10\text{ m/s}^2)(0.5\text{ m}) = 10\text{ J}$$

$$\text{But}\quad E_K = \frac{mv^2}{2} \quad \therefore\ v^2 = \frac{2E_K}{m} = \frac{2(10\text{ J})}{5\text{ kg}} = 4\text{ m}^2/\text{s}^2 \quad \therefore\ v = 2\text{ m/s}$$

9. A 2 kg mass, whose velocity at point-A is 20 m/s, slides along a frictionless ramp as illustrated below. What is the velocity of the mass at point-B? [17.3 m/s]



$$\text{At point–A:}\quad E_T = E_P + E_K = mgh + \frac{mv^2}{2} = (2\text{ kg})(10\text{ m/s}^2)(2\text{ m}) + \frac{(2\text{ kg})(20\text{ m/s})^2}{2} = 440\text{ J}$$

$$\text{At point–B:}\quad E_T = E_P + E_K \quad \therefore\ E_K = E_T - E_P = E_T - mgh = 440\text{ J} - (2\text{ kg})(10\text{ m/s}^2)(7\text{ m}) = 300\text{ J}$$

$$\text{But}\quad E_K = \frac{mv^2}{2} \quad \therefore\ v^2 = \frac{2\,E_K}{m} = \frac{2(300\text{ J})}{2\text{ kg}} = 300\text{ m}^2/\text{s}^2 \quad \therefore\ v = 17.3\text{ m/s}$$

10. The hammer of a pile driver has a mass of 500 kg. The hammer is raised 4 m above the pile and released. If the pile sinks 0.25 m into the ground, calculate the average force of the hammer. [80 000 N]

$$W = E_K - mgh = Fs$$

$$\therefore\ F = \frac{mgh}{s} = \frac{(500\text{ kg})(10\text{ m/s}^2)(4\text{ m})}{0.25\text{ m}} = 80\ 000\text{ N}$$

11. A 50 kg student runs up 2 flights of stairs, a vertical distance of 8 m. How much work does the student do? [4 000 J]

$$W = E_P = mgh = (50\text{ kg})(10\text{ m/s}^2)(8\text{ m}) = 4\ 000\text{ J}$$

12. A 2 kg block, whose velocity at point-A is 5 m/s, slides down ramp whose height is 10 m. When the block reaches point-B, the bottom of the ramp, its speed is 10 m/s. What is the energy lost due to friction? [125 J]

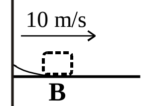
Find total energy at point – A:

$$E_T = E_P + E_K = mgh + \frac{mv^2}{2} = (2\,kg)(10\,m/s^2)(10\,m) - \frac{(2\,kg)(5\,m/s)^2}{2} = 225\,J$$

Find total energy at point – B:

$$E_T = E_P + E_K = mgh + \frac{mv^2}{2} = (2\,kg)(10\,m/s^2)(0) - \frac{(2\,kg)(10\,m/s)^2}{2} = 100\,J$$

Thus, $\Delta E = E_F - E_I = 100\,J - 225\,J = -125\,J$



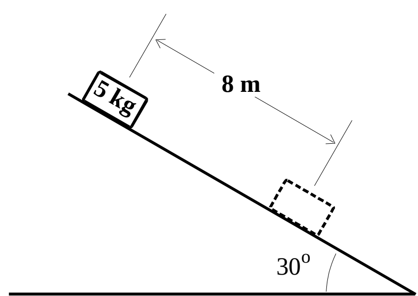
13. A 1.0 kg stone drops from a height of 5.0 m above the ground. What is its kinetic energy when it is at a height of 2.0 m from the ground? [30 J]

E_T **at 5.0 m from ground:** $E_T = E_P + E_K = mgh + 0 = (1.0\,kg)(10\,m/s^2)(5.0\,m) = 50\,J$

E_P **at 2.0 m from ground:** $E_P = mgh = (1.0\,kg)(10\,m/s^2)(5.0\,m) = 20\,J$

$\because\ E_T = E_P + E_K \quad \therefore\ E_K = E_T - E_P = 50\,J - 20\,J = 30\,J$

14. From rest, a 5 kg block slides down a frictionless plane inclined at an angle of 30^o from the horizontal. Calculate the work done by the gravitational force for a displacement of 8 m along the plane. [200 J]



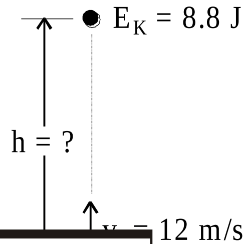
Find the height that the block slides down.

$h = (8\,m)(\sin 30^o) = 4\,m$

Now find the E_P **(work done) at the top.**

$E_P = mgh = (5\,kg)(10\,m/s^2)(4\,m) = 200\,J$

15. A 400 g metal sphere is fired vertically into the air with a velocity of 12 m/s. At what height above the ground will its kinetic energy be 8.8 J. [5 m]

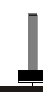


$$\mathbf{E_P = \Delta E_K = E_{K\,Final} - E_{K\,Initial}}$$
$$\mathbf{= 8.8\ J - \frac{1}{2}mv^2}$$
$$\mathbf{= 8.8\ J - \frac{1}{2}(0.4\ kg)(12\ m/s)^2}$$
$$\mathbf{= 8.8\ J - 28.8\ J}$$
$$\mathbf{= -20\ J}$$

Negative sign indicates the decrease (loss) in K_E which equals the increase (gain) in E_P.

$$\mathbf{E_P = mgh}$$
$$\mathbf{h = \frac{E_P}{mg}}$$
$$\mathbf{h = \frac{20\ J}{(0.4\ kg)(10\ m/s^2)}}$$
$$\mathbf{h = 5\ m}$$

16. A hammer falls from a scaffold and 1.5 s later strikes the ground with a kinetic energy of 157.5 J. What is the weight of the hammer? [14 N]



Since we are told that the time of fall is 1.5 s, we can calculate the height.

$$\mathbf{s = v_i t + \frac{at^2}{2} = 0(1.5\ s) + \frac{(10\ m/s^2)(1.5\ s)^2}{2} = 11.25\ m}$$

Since the E_P at the top equals the E_K at the bottom.

or : $\mathbf{E_P = E_K}$

or : $\mathbf{mgh = 157.5\ J}$

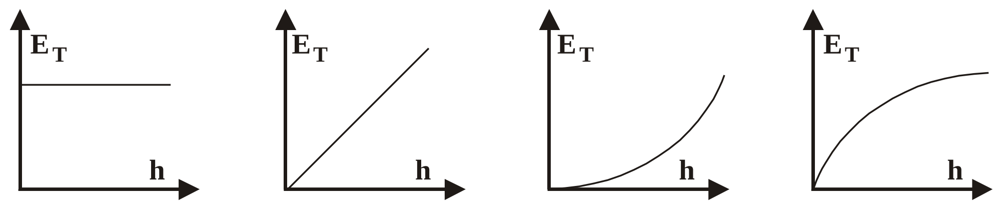
$$\mathbf{\therefore\ m = \frac{157.5\ J}{gh} = \frac{157.5\ J}{(10\ m/s^2)(11.25\ m)} = 1.4\ kg}$$

Thus : $\mathbf{w = mg = (1.4\ kg)(10\ m/s^2) = 14\ N}$

17. Object-A has mass m and is a distance h from the ground. Object-B has mass 5m and is a distance of 2h from the ground. What is the value of the following ratio?

$$\frac{\text{Potential energy of Object-A}}{\text{Potential energy of Object-B}} \qquad \frac{\mathbf{m_A g h_A}}{\mathbf{m_B g h_B}} = \frac{\mathbf{m_A h_A}}{\mathbf{m_B h_B}} = \frac{\mathbf{mh}}{\mathbf{5m \cdot 2h}} = \frac{\mathbf{1}}{\mathbf{10}}$$

18. An object is thrown up into the air. Which of the following graphs correctly represents the ***total energy*** of the object as a function of height?



(A) **(B)** **(C)** **(D)**

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