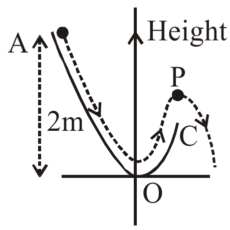
# WORK POWER ENERGY

**1.** A 60 HP electric motor lifts an elevator having a maximum total load capacity of 2000 kg. If the frictional force on the elevator is 4000 N, the speed of the elevator at full load is close to: (1 HP = 746 W, g = 10 $ms^{-2}$)

(1) 1.7 $ms^{-1}$
(2) 2.0 $ms^{-1}$
(3) 1.9 $ms^{-1}$
(4) 1.5 $ms^{-1}$

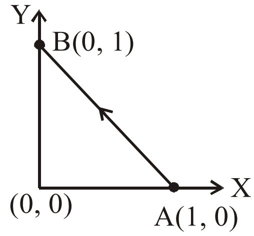
**2.** A particle (m = 1 kg) slides down a frictionless track (AOC) starting from rest at a point A (height 2 m). After reaching C, the particle continues to move freely in air as a projectile. When it reaching its highest point P (height 1 m), the kinetic energy of the particle (in J) is : (Figure drawn is schematic and not to scale; take g=10 $ms^{-2}$)______.




**3.** An elevator in a building can carry a maximum of 10 persons, with the average mass of each person being 68 kg. The mass of the elevator itself is 920 kg and it moves with a constant speed 3 m/s. The frictional force opposing the motion is 6000 N. If the elevator is moving up with its full capacity, the power delivered by the motor to the elevator (g = 10 $m/s^2$) must be at least :

(1) 56300 W
(2) 48000 W
(3) 66000 W
(4) 62360 W

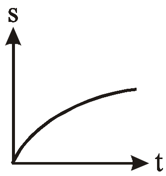
**4.** Consider a force $\vec{F} = -x\hat{i} + y\hat{j}$. The work done by this force in moving a particle from point A(1, 0) to B(0, 1) along the line segment is : (all quantities are in SI units)

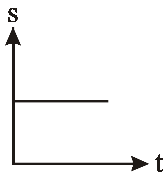


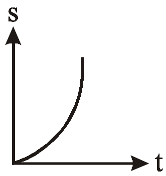

(1) $\frac{3}{2}$
(2) 1
(3) 2
(4) $\frac{1}{2}$

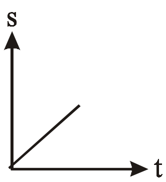
**5.** A cricket ball of mass 0.15 kg is thrown vertically up by a bowling machine so that it rises to a maximum height of 20 m after leaving the machine. If the part pushing the ball applies a constant force F on the ball and moves horizontally a distance of 0.2 m while launching the ball, the value of F(in N) is (g = 10 $ms^{-2}$)_______.

**6.** A particle is moving unidirectionally on a horizontal plane under the action of a constant power supplying energy source. The displacement (s) - time (t) graph that describes the motion of the particle is (graphs are drawn schematically and are not to scale) :

(1)



(2)



(3)



(4)



**7.** A person pushes a box on a rough horizontal platform surface. He applies a force of 200 N over a distance of 15 m. Thereafter, he gets progressively tired and his applied force reduces linearly with distance of 100 N. The total distance through which the box has been moved is 30 m. What is the work done by the person during the total movement of the box ?

(1) 5690 J

(2) 5250 J

(3) 3280 J

(4) 2780 J

**8.** A body of mass 2kg is driven by an engine delivering a constant power 1J/s. The body starts from rest and moves in a straight line. After 9 seconds, the body has moved a distance (in m) _______.

**9.** If the potential energy between two molecules is given by $U = \frac{A}{r^6} + \frac{B}{r^{12}}$, then at equilibrium, separation between molecules, and the potential energy are :

(1) $\left(\frac{B}{A}\right)^{1/6}, 0$

(2) $\left(\frac{B}{2A}\right)^{1/6}, -\frac{A^2}{2B}$

(3) $\left(\frac{2B}{A}\right)^{1/6}, -\frac{A^2}{4B}$

(4) $\left(\frac{2B}{A}\right)^{1/6}, -\frac{A^2}{2B}$

**10.** A particle moving in the xy plane experiences a velocity dependent force $\vec{F} = k(v_y\hat{i} + v_x\hat{j})$, where $v_x$ and $v_y$ are the x and y components of its velocity $\vec{v}$. If $\vec{a}$ Ls the acceleration of the particle, then which of the following statements is true for the particle ?

(1) quantity $\vec{v}\cdot\vec{a}$ is constant in time.

(2) kinetic energy of particle is constant in time.

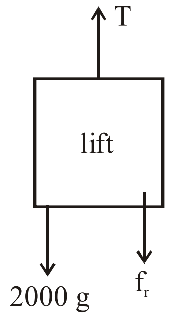
(3) quantity $\vec{v}\times\vec{a}$ is constant in lime.

(4) $\vec{F}$ arises due to a magnetic field.

## SOLUTION

**1. NTA Ans. (3)**

**Sol.**




Let elevator is moving upward with constant speed V.

Tension in cable

T = 2000 g + $f_r$ = 2000 + 4000

T = 24000 N

Power P = TV

$\Rightarrow$ 60 × 746 = (24000) V

$$V = \frac{60 \times 746}{24000} = 1.865 \approx 1.9 \text{ m/s.}$$

**2. NTA Ans. (10)**

**Sol.** Mechanical energy conservation between A & P

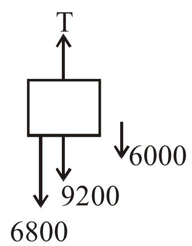
$$U_1 + \cancel{K_1}^{\,0} = K_2 + U_2$$

mg × 2 = mg × 1 + $K_2$

$K_2$ = mg × 1 = 10 J.

**3. NTA Ans. (3)**

**Sol.**




elevater moving with constant speed hence

T = 6800 + 9200 + 6000

T = 22000 N

power = T·v = 22000 × 3

= 66000 W

**4. NTA Ans. (2)**

**Sol.** $$W = \int_{\vec{r}_i}^{\vec{r}_g} \vec{F}.d\vec{r}$$

$$W = \int_1^0 -x dx + \int_0^1 y dy$$

$$W = \left.\frac{-x^2}{2}\right|_1^0 + \left.\frac{y^2}{2}\right|_0^1$$

$$= -\left(\frac{0^2}{2} - \frac{1^2}{2}\right) + \left(\frac{1^2}{2} - \frac{0^2}{2}\right)$$

W = 1J

**5. Official Ans. by NTA (150)**

**Sol.** $W_F = \frac{1}{2}mv^2 = mgh$

F(S) = mgh

F(0.2) = (0.15) (10) (20)

$\boxed{F = 150N}$

**6. Official Ans. by NTA (3)**

**Sol.** $$\frac{dK}{dE} = P = \text{cost} \Rightarrow K = Pt = \frac{1}{2}mV^2$$

$$\therefore \; V = \sqrt{\frac{2Pt}{m}} = \frac{ds}{dt} \therefore S = \sqrt{\frac{2P}{m}}\frac{2}{3}t^{\frac{3}{2}}$$

**7. Official Ans. by NTA (2)**

**Sol.** F = 200 N for $0 \le x \le 15$

$= 200 - \frac{100}{15}(x - 15)$ for $15 \le x < 30$

$W = \int F\,dx$

$$= \int_0^{15} 200\,dx + \int_{15}^{30}\left(300 - \frac{100}{15}x\right)dx$$

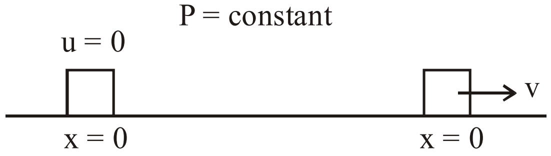
$$= 200 \times 15 + 300 \times 15 - \frac{100}{15} \times \frac{(30^2 - 15^2)}{2}$$

= 3000 + 4500 – 2250

= 5250 J

**8. Official Ans. by NTA (18.00)**

**Sol.**




P = mav

$$m\frac{dv}{dt}v = P$$

$$\int_0^v v\,dv = \frac{P}{m}\int_0^t dt$$

$$\frac{v^2}{2} = \frac{Pt}{m} \Rightarrow v = \left(\frac{2Pt}{m}\right)^{1/2}$$

$$\frac{dx}{dt} = \sqrt{\frac{2P}{m}}\,t^{1/2}$$

$$\int_0^x dx = \sqrt{\frac{2P}{m}}\int_0^t t^{1/2}\,dt$$

$$x = \sqrt{\frac{2P}{m}}\frac{t^{3/2}}{3/2} = \sqrt{\frac{2P}{m}} \times \frac{2}{3}t^{3/2}$$

$$= \sqrt{\frac{2\times 1}{2}} \times \frac{2}{3} \times 9^{3/2}$$

$$= \frac{2}{3} \times 27 = 18$$

**9. Official Ans. by NTA (3)**

**Sol.** $U = \frac{-A}{r^6} + \frac{B}{r^{12}}$

$$F = -\frac{dU}{dr} = -\left(A\left(-6r^{-7}\right)\right) + B\left(-12r^{-13}\right)$$

$$0 = \frac{6A}{r^7} - \frac{12B}{r^{13}}$$

$$\frac{6A}{12B} = \frac{1}{r^6} \Rightarrow r = \left(\frac{2B}{A}\right)^{1/6}$$

$$U\left(r = \left(\frac{2B}{A}\right)^{1/6}\right) = -\frac{A}{2B/A} + \frac{B}{4B^2/A^2}$$

$$= \frac{-A^2}{2B} + \frac{A^2}{4B} = \frac{-A^2}{4B}$$

**10. Official Ans. by NTA (3)**

**Sol.** $\frac{dv_x}{dt} = \frac{k}{m}v_y$

$$\frac{dv_y}{dt} = \frac{k}{m}v_x$$

$$\frac{dv_y}{dv_x} = \frac{v_x}{v_y} \Rightarrow \int v_y dv_y = \int v_x dv_x$$

$$v_y^2 = v_x^2 + C$$

$$v_y^2 - v_x^2 = \text{constant}$$

Option (3)

$$\vec{v} \times \vec{a} = (v_x\hat{i} + v_y\hat{j}) \times \frac{k}{m}(v_y\hat{i} + v_x\hat{j})$$

$$= (v_x^2\hat{k} - v_y^2\hat{k})\frac{k}{m}$$

$$= (v_x^2 - v_y^2)\frac{k}{m}\hat{k}$$

= Constant