

WS-16 - Power
Thank

9th foundation + ①

①

Given power = 2 kw ; $t = 1 \text{ min} = 60 \text{ sec}$
 $h = 10 \text{ m}$

we know that $P = \frac{W}{t}$

$$P = \frac{mgh}{t}$$

$$2 \times 10^3 = \frac{m \times 10 \times 10}{60}$$

$$m = 2 \times 10^2 \times 6 = 1200 \text{ kg} \rightarrow D$$

②

Given $W = mg = 750 \text{ N}$; $h = 15 \text{ m}$; $t = 5 \text{ sec}$

work done by the machine = mgh

$$= 750 \times 15$$

$$= 11250$$

$$= 11.250 \text{ kJ}$$

③

Given weight = $mg = 750 \text{ N}$; $h = 15 \text{ m}$; $t = 5 \text{ sec}$

$$\text{Power} = \frac{W}{t} = \frac{mgh}{t} = \frac{750 \times 15}{5} = 2250 = 2.25 \text{ kw}$$

④

Given $m = 100 \text{ kg}$; $h = 3 \text{ m}$; $t = 10 \text{ sec}$

$$\text{Power} = \frac{W}{t} = \frac{mgh}{t} = \frac{100 \times 10 \times 3}{10} = 300 \text{ W}$$

(2)

(5)

If a liquid of density ρ is flowing through a pipe of cross section A at speed v , the mass coming out per second will be

$$\frac{dm}{dt} = \rho A v$$

In order to get 'n' times of water in the same time, we get

$$\left(\frac{dm}{dt}\right)' = n \frac{dm}{dt} \Rightarrow A' v' \rho' = n A v \rho$$

Here pipe and liquid are same $A' = A$; $\rho' = \rho$

$$\therefore v' = n v$$

$$\therefore \frac{F'}{F} = \frac{v' \left(\frac{dm}{dt}\right)'}{v \left(\frac{dm}{dt}\right)} \quad \left[\text{From Newton's II}^{\text{nd}} \text{ law} \right. \\ \left. F = \frac{dp}{dt} = v \frac{dm}{dt} \right]$$

$$\therefore \frac{F'}{F} = \frac{n v \cdot n \frac{dm}{dt}}{v \frac{dm}{dt}} = n^2 \Rightarrow F' = n^2 F$$

We know power $P = F v$

$$\text{New power } P' = F' v' \Rightarrow P' = n^2 F \cdot n v = n^3 F v$$

$$P' = n^3 P$$

$$\text{Given } P' \propto n^k P \quad \therefore k = 3 \rightarrow A$$

(6)

$$\text{Given } P = 3b^2$$

$$\Rightarrow \frac{dw}{dt} = 3b^2$$

$$\Rightarrow w = \int 3b^2 dt$$

We know According to w-E theorem

$$w = \Delta K.E$$

$$\Rightarrow \Delta K.E = \int_2^4 3b^2 dt$$

$$= 3 \left[\frac{t^3}{3} \right]_2^4 \quad \left(\int x^n dx = \frac{x^{n+1}}{n+1} \right)$$

$$= (4^3 - 2^3)$$

$$= 56 \text{ J} \rightarrow c.$$



⑦

Given Force $F = \frac{k}{v} \Rightarrow k = F v$

Since work done = $F \cdot s$

we know displacement = velocity $\times$ time
 $= v t$

$\therefore W = F v t$

$W = k t \rightarrow c$

⑧

Given $m_b = 0.5 \text{ kg} \quad ; \quad v_{\text{man}} = 1 \text{ m/s}$

$u_{\text{ball}} = 25 \text{ m/s} \quad h = 0.5$

we know Power = $\frac{dw}{dt}$

According to $w-E$ Theorem $w = \Delta k \cdot E$

$w_{\text{man}} + w_g = \Delta k \cdot E$

$\Rightarrow w_{\text{man}} - m g h = \frac{1}{2} m v^2 - \frac{1}{2} m u_{\text{man}}^2$

$\Rightarrow w_{\text{man}} - 0.5 \times 10 \times 0.5 = \frac{1}{2} m (v^2 - u_m^2)$

$\Rightarrow w_{\text{man}} - 2.5 = \frac{1}{2} \times \frac{1}{2} (25^2 - 1^2)$

$\Rightarrow w_{\text{man}} - \frac{10}{4} = \frac{1}{4} \times 624$

$\Rightarrow w_{\text{man}} = \frac{634}{4}$

Power = $\frac{w_{\text{man}}}{t} = \frac{634}{4 \times 5} = \frac{634}{20} = \frac{63.4}{2} = 31.7 \text{ W}$

⑨

Given velocity = 100 kmph = $100 \times \frac{5}{18}$ m/s

$$F = 3920 \text{ N}$$

Power wasted = 20%

So 80% of power used

$$\therefore 80\% P = F V$$

$$\Rightarrow \frac{80}{100} P = 3920 \times 100 \times \frac{5}{18}$$

$$\Rightarrow P = 3920 \times 100 \times \frac{5}{18} \times \frac{100}{80}$$

$$= 13.16 \times 10^4 \text{ W in Hp}$$

$$P = \frac{13.16 \times 10^4}{748} = 182.5 \text{ hp}$$

(10) Given Volume $V = 30 \text{ m}^3$; time $t = 15 \text{ min} = 15 \times 60 \text{ sec}$

$$h = 40 \text{ m} ; \eta = 30\% ; \rho_{\text{water}} = 10^3 \text{ kg/m}^3$$

$$m_{\text{water}} = \rho V = 10^3 \times 30 = 30 \times 10^3 \text{ kg.}$$

$$\text{work done } W = mgh = 30 \times 10^3 \times 9.8 \times 40 = 11760 \text{ kJ}$$

$$P_{\text{out}} = mgh \times t = 11760 \times 10^3 \times 15 \times 60 = 13.066 \text{ kW}$$

$$\eta = \frac{P_{\text{out}}}{P_{\text{in}}} \Rightarrow \frac{30}{100} = \frac{13.066}{P_{\text{in}}}$$

$$P_{\text{in}} = 43.6 \text{ kW} \rightarrow A$$

(14), (15), (16)

Given power = 2 H.P = 2 \times 748 W

$$\eta = 75\% = \frac{75}{100} = \frac{3}{4}$$

$$\frac{P_{\text{out}}}{P_{\text{in}}} = \frac{3}{4} \Rightarrow P_{\text{out}} = \frac{3}{4} P_{\text{in}} = \frac{3}{4} \times 2 \times 748$$

$$\Rightarrow P_{\text{out}} = 1122 \text{ W.}$$

if the 2nd machine is connected, output of 1st machine will act as input for 2nd machine.

and given input for 2nd machine also 2 H.P = 2 \times 748

$$\therefore \text{so 1st efficiency } \eta = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100 = \frac{1122}{2 \times 748} \times 100$$

$$\eta = 75\%$$

\therefore \text{Over all efficiency} = 75\%

(16) Given $\eta = 50\%$

$$\frac{P_{\text{out}}}{P_{\text{in}}} = \frac{50}{100}$$

$$\Rightarrow P_{\text{out}} = \frac{1}{2} P_{\text{in}} = \frac{1}{2} \times 2 \text{ H.P} = 1 \text{ H.P} \rightarrow A$$



①

Given volume = 60 lit = $60 \times 10^{-3} \text{ m}^3$

$h = 20 \text{ m}$; $t = 5 \text{ sec}$

$M_{\text{water}} = d \times \text{vol} = 10^3 \times 60 \times 10^{-3} = 60 \text{ kg}$

Power = $\frac{W}{t} = \frac{Mgh}{t} = \frac{60 \times 10 \times 20}{5} = 2400 \text{ W} \rightarrow B$

②

Given $m = 5 \text{ kg}$; $h = 10 \text{ m}$; $t = 10 \text{ sec}$

Power = $\frac{W}{t} = \frac{Mgh}{t} = \frac{5 \times 10 \times 10}{10} = 50 \text{ W} \rightarrow A$

③

Given $m = 20 \text{ kg}$; $h = 5 \text{ m}$; $t = 2 \text{ sec}$

Power = $\frac{W}{t} = \frac{Mgh}{t} = \frac{20 \times 10 \times 5}{2} = 500 \text{ W} \rightarrow C$

④

Given No. of stairs = 25 ; $m = 60 \text{ kg}$; $t = 3 \text{ sec}$

height of each stair = $20 \text{ cm} = 20 \times 10^{-2} \text{ m}$

Total height = $nh = 25 \times 20 \times 10^{-2} = 5 \text{ m}$

Power = $\frac{W}{t} = \frac{mgh}{t} = \frac{60 \times 10 \times 5}{3} = 1000 \text{ W}$

⑤

Given $m = \frac{10}{7} \text{ kg}$; initial velocity $u = 1 \text{ m/s}$

We know

$P = \frac{W}{t}$ From graph $P = 0.2x + 2$

$\Rightarrow FV = 0.2x + 2$

$\Rightarrow m a v = 0.2x + 2$

$\Rightarrow m \frac{dv}{dt} v = 0.2x + 2$

$$\Rightarrow m v \frac{dv}{dx} \frac{dx}{dt} = 0.2x + 2$$

$$\Rightarrow m v \frac{dv}{dx} (v) = 0.2x + 2$$

$$\Rightarrow m v^2 dv = (0.2x + 2) dx$$

$$\int_1^v m v^2 dv = \int_1^{10} (0.2x + 2) dx$$

$$\Rightarrow m \left[\frac{v^3}{3} \right]_1^v = \frac{0.2}{2} \left[\frac{x^2}{2} \right]_0^{10} + 2[x]_0^{10}$$

$$= \frac{10}{7} \left[\frac{v^3 - 1}{3} \right] = 0.1 [10^2 - 0] + 2[10 - 0]$$

$$\Rightarrow \frac{10}{7} \left[\frac{v^3 - 1}{3} \right] = 10 + 20$$

$$\Rightarrow v^3 - 1 = 3 \times 3 \times 7$$

$$v^3 = 64 \Rightarrow v = 4 \text{ m/s} \rightarrow A$$

(6)

Given

$$m = 1000 \text{ kg}, \quad h = 100 \text{ m}, \quad t = 0.5 \text{ s}$$

$$\text{Actual power} = \frac{mgh}{t} = \frac{100 \times 10 \times 100}{0.5} = 2 \times 10^5 \text{ W}$$

$$\text{Power required} = \frac{\text{Actual power}}{\eta} = \frac{2 \times 10^5}{\frac{25}{100}}$$

$$= \frac{200 \times 10^5}{25} = 800 \text{ kW} \rightarrow B$$

(7)

let

$$\text{mass of each coach } m_c = m$$

$$\text{mass of engine } m_e = 2m$$

$$\therefore \text{total weight } F = 4m_c + m_e = 4m + 2m = 6m$$

$$\text{Power } P = Fv = 6mgv \rightarrow (1)$$

$$\text{For 12 coaches } F = 12m + 2m = 14m$$

(5)

Power $P' = F v_1 = 14mg v_1 \rightarrow (2)$

$$P = P'$$

$$\Rightarrow 6mgv = 14mg v_1$$

$$\Rightarrow v_1 = \frac{6}{14} v \quad \text{Given } v = 20 \text{ m/s}$$

$$\Rightarrow v_1 = \frac{6}{14} \times 20 = \underline{8.5 \text{ m/s}}$$

For 6 coaches

$$\text{Force} = 6m_c + m_e = 6m + 2m = 8m$$

$$\text{Power} = F v_2 = 8mg v_2 \rightarrow (3)$$

$\therefore$ (1) and (3)

$$6mgv = 8mg v_2$$

$$\Rightarrow v_2 = \frac{6}{8} \times 20 = \underline{15 \text{ m/s}} \rightarrow A$$

(8)

$$\text{mass of coal} = 20 \text{ ton} = 20 \times 10^3 \text{ kg}$$

$$t_{me} = 2 \text{ sec} \quad g = 10 \text{ m}$$

$$\text{Power} = \frac{W}{t} = \frac{F \cdot S}{t} = \frac{20 \times 10^3 \times 100}{2} = 1000 \text{ kW}$$

$$\langle \text{Power} \rangle = \frac{1}{2} \langle P_{\text{instantaneous}} \rangle = \frac{1000}{2} = 500 \text{ kW} \rightarrow A$$

(9)

Given $F = 4\hat{i} - 3\hat{j} + 2\hat{k} \text{ N}$

$$\begin{aligned} \text{Displacement } \vec{S} &= (-3+2)\hat{i} + (-1+2)\hat{j} + (4+1)\hat{k} \\ &= -\hat{i} - 3\hat{j} + 5\hat{k} \end{aligned}$$

$$\begin{aligned} \text{Power work} &= \vec{F} \cdot \vec{S} = [4\hat{i} - 3\hat{j} + 2\hat{k}] \cdot [-\hat{i} - 3\hat{j} + 5\hat{k}] \\ &= -4 \times 1 + (-3)(-3) + 2(5) \\ &= -4 + 9 + 10 = 15 \text{ J} \rightarrow B \end{aligned}$$



(10)

Given $m_{\text{water}} = 2000 \text{ kg}$

height of dam = 550 m

height of power house = 50 m

$$\text{Power} = \frac{W}{t} = \frac{mg \Delta h}{t} = \frac{2000 \times 10 \times (550 - 50)}{1} \\ = 10 \text{ MW}$$

efficiency = 80%

$$P_{\text{out}} = \eta \times P_{\text{in}} = \frac{80}{100} \times 10 \text{ MW} = 8 \text{ MW} \rightarrow \text{B}$$

(14)

Given $F = 150 \text{ N}$, $S = 20 \text{ m}$, $t = 2 \text{ sec}$

$$\text{Power} = \frac{W}{t} = \frac{F \cdot S}{t} = \frac{150 \times 20}{2} = 1500 \text{ W} \rightarrow \text{C}$$

(15)

Given $W = 2500 \text{ J}$, $t = 5 \text{ sec}$

$$\text{Power} = \frac{W}{t} = \frac{2500}{5} = 500 \text{ W} \rightarrow \text{A}$$

(16)

we know

$$P = \frac{W}{t} = \frac{\Delta K \cdot E}{t}$$

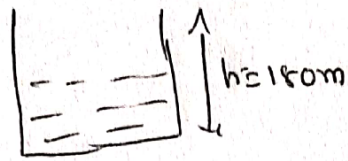
$$P = \frac{\frac{1}{2} m v^2}{\frac{s}{v}} \Rightarrow P = \frac{1}{2} \frac{m}{s} v^3$$

$$P \propto v^3$$

Given $P_1 = P$, $P_2 = 2P$

$$\therefore \frac{P_2}{P_1} = \left(\frac{v_2}{v_1} \right)^3 \Rightarrow \frac{2P}{P} = \left(\frac{v_2}{v} \right)^3 \Rightarrow v_2 = (2)^{\frac{1}{3}} v \rightarrow \text{A}$$

(17)



$$m = 10,000 \text{ kg} ; \quad t = 1 \text{ hr}$$

$$= 10 \times 10^3 \text{ kg} \quad = 3600 \text{ s}$$

$$P = \frac{W}{t} = \frac{mgh}{t} = \frac{10 \times 10^3 \times 10 \times 180}{3600}$$

$$= 5 \times 10^3 \text{ W}$$

$$P_{in} = \frac{P}{\eta} = \frac{5 \times 10^3}{80\%} = \frac{5}{\frac{80}{100}} \times 10^3 = \frac{50}{8} \times 10^3 = 6.25 \text{ kW}$$

(18)

Given

$$F = 4000 \text{ N} ; \quad v = 3 \text{ m/s}$$

$$P = Fv = 4000 \times 3 = 12000 \text{ W}$$

$$1 \text{ kWh} = 3.6 \times 10^5 \text{ J} \quad = 12 \times 10^3 \text{ W}$$

$$= 12 \text{ kW}$$

(19)

$$P_{in} = K ; \quad P_{out}$$

$$\textcircled{1} \quad \eta = \frac{P_{out}}{P_{in}} \Rightarrow P_{in} = \frac{P_{out}}{\eta} = \frac{100}{\frac{50}{100}} = \frac{100}{0.5} = 200 \text{ W} \rightarrow C$$

$$\textcircled{2} \quad P_{in} = 60 \text{ W} ; \quad \eta = 20\% = \frac{1}{5} \Rightarrow P_{out} = \eta \times P_{in} = \frac{1}{5} \times 60 = 12 \text{ W} \rightarrow D$$

$$\textcircled{3} \quad P_{in} = P_{out} \Rightarrow \eta = \frac{P_{out}}{P_{in}} = 1 = 100\% \rightarrow A$$

$$\textcircled{4} \quad \eta = 20\% = \frac{1}{5} \Rightarrow P_{in} = \frac{P_{out}}{\eta} = \frac{450}{\frac{1}{5}} = 2250 \text{ W} \rightarrow B$$

$$P_{out} = 450$$