MCQ 50 marks

1. **C.** $\frac{v_e}{2}$

Explanation: From mass conservation, $M = \frac{4}{3}\pi\varrho R^3$

For the same M with $\varrho_P = \frac{\varrho_E}{8}$: $R_P^3 = 8R_E^3 \Rightarrow R_P = 2R_E$

Energy conservation to the center of a uniform sphere (radius R): $v_{center}^2 = \frac{GM}{R}$

So, $v_P^2 = \frac{GM}{R_P}$

Here, Earth's escape velocity $v_e^2 = \frac{2GM}{R_E} = \frac{2GM}{R_P/2} = \frac{4GM}{R_P}$

Therefore, $\frac{v_P^2}{v_e^2} = \frac{GM/R_P}{4GM/R_P} = \frac{1}{4} \Rightarrow v_P = \frac{v_e}{2}$

2. **A.** 1.352×10^{10} N

Explanation: Angular velocity, $\omega = \frac{2\pi}{T} = \frac{2\pi}{13\times3600} \approx 1.3427 \times 10^{-4}$ rads^{-1}

Radius, $R = \frac{\text{diameter}}{2} = 7.5 \times 10^8$ m

Weight loss at the equator, $\Delta W = m\omega^2 R$

$\Delta W = 10^9 \times (1.3427 \times 10^{-4})^2 \times 7.5 \times 10^8$

Therefore, $\Delta W \approx 1.352 \times 10^{10}$ N

3. **C.** 0.113 HP

Explanation: Height, $h = 45 \sin 55° = 36.86$ m

Total mass, $m = 60 + 10 = 70$ kg

Work, $W = mgh = 70 \times 9.8 \times 36.86 = 25287.22$ J

Time, $t = 5$ min $= 300$ s

Power, $P = \frac{W}{t} = 84.29$ W

Therefore, $P = \frac{84.29}{746} \approx 0.113$ HP

4. **A.** 10, 000 N

Explanation: Kinetic energy of the bullet, $KE = \frac{1}{2}(0.015)(400)^2 = 1200$ J

By the work-energy theorem, $F = \frac{KE}{d} = \frac{1200}{0.12}$

Therefore, $F = 10,000$ N

5. **C.** 85.625 m

Explanation: Given, $KE = \frac{3}{5}PE$.

Using the shortcut formula,

$h = \frac{H}{1+\frac{KE}{PE}}$

$= \frac{137}{1+\frac{3}{5}}$

$= \frac{137}{\frac{8}{5}}$

$= \frac{137\times5}{8}$

$= 85.625$ m

6. **B.** $1 : 4 \times 10^{19}$

Explanation: Since only the internal (mutual) force acts, momentum is conserved: $m_1 v_1 = m_2 v_2$

So, $\frac{v_1}{v_2} = \frac{m_2}{m_1} = \frac{5\times10^7}{2\times10^{27}}$

Therefore, $\frac{v_1}{v_2} = \frac{1}{4\times10^{19}}$

Note that the radii would be needed to find the actual speed values, but the ratio depends only on the mass ratio.

7. **D.** 57, 600 km

Explanation: $\frac{R^2}{(R+h)^2} = 0.01 \Rightarrow \frac{R}{R+h} = 0.1$

Here, $R + h = 10R \Rightarrow h = 9R$

Since $R = 6400$ km, $h = 9 \times 6400$

Therefore, $h = 57,600$ km

8. **B.** 1080.06 J

Explanation: Normal force, $N = mg - F \sin 40° = 196 - 96.42 = 99.58$ N

Friction force, $f = \mu N = 24.90$ N

Work by applied force, $W_F = F \cos 40° \times d = 150 \times 0.766 \times 12 = 1378.8$ J

Work by friction, $W_f = -f \times d = -24.90 \times 12 = -298.75$ J

Net work, $W = W_F + W_f = 1378.8 - 298.75$

Therefore, $W \approx 1080.06$ J

9. **C. Exactly the same**

Explanation: Inside a uniform-density Earth, motion in any straight tunnel (chord or diameter) is simple harmonic motion (SHM)

This SHM always has the same angular frequency $\omega = \sqrt{\frac{g}{R}}$, regardless of the chord's length or position

Therefore, $T = 2\pi\sqrt{\frac{R}{g}}$ is identical in every case — a well-known surprising result

10. **C.** 4828 km

Explanation: $\frac{g_1}{g_2} = \frac{(R+h_2)^2}{(R+h_1)^2} \Rightarrow \frac{4.9}{3.728} = \frac{(R+3000)^2}{(R+2000)^2}$

Here, $1.3144 = \left(\frac{R+3000}{R+2000}\right)^2 \Rightarrow \sqrt{1.3144} = \frac{R+3000}{R+2000}$

$1.1465 = \frac{R+3000}{R+2000} \Rightarrow 1.1465(R+2000) = R+3000$

$1.1465R + 2293 = R + 3000 \Rightarrow 0.1465R = 707$

Therefore, $R \approx 4826\,\text{km}$

11. **B.** $2.432 \times 10^7\,\text{s}$

Explanation: Two-body Kepler's law: $T^2 = \frac{4\pi^2 a^3}{G(M_1+M_2)}$

Here, $a = 2 \times 10^{11}\,\text{m}$ and $M_1 + M_2 = 8 \times 10^{30}\,\text{kg}$

This gives $T^2 \approx 5.916 \times 10^{14}$

Therefore, $T \approx 2.432 \times 10^7\,\text{s} \approx 281$ days

12. **D.** $65.33\,\text{W}$

Explanation: Work per lift, $W_1 = mgh = 20 \times 9.8 \times 1.6 = 313.6\,\text{J}$

Total work, $W = 25 \times 313.6 = 7840\,\text{J}$

Time, $t = 2\,\text{min} = 120\,\text{s}$

Power, $P = \frac{W}{t} = \frac{7840}{120}$

Therefore, $P \approx 65.33\,\text{W}$

13. **A.** $491.16\,\text{J}$

Explanation: Volume, $V = 0.45 \times 0.55 \times 0.75 = 0.185625\,\text{m}^3$

Mass, $m = 1800 \times 0.185625 = 334.125\,\text{kg}$

Rise of centre of mass, $\Delta h = \frac{0.75}{2} - \frac{0.45}{2} = 0.15\,\text{m}$

Work, $W = mg\Delta h = 334.125 \times 9.8 \times 0.15$

Therefore, $W \approx 491.16\,\text{J}$

14. **A.** $2185\,\text{W}$

Explanation: Power delivered to the sand each second: $P = \dot{m}\left(gh + \frac{1}{2}v^2\right)$

Here, $\dot{m} = 50\,\text{kgs}^{-1}$, $gh = 9.8 \times 4 = 39.2$ and $\frac{1}{2}v^2 = \frac{1}{2}(3)^2 = 4.5$

So, $P = 50 \times (39.2 + 4.5) = 50 \times 43.7$

Therefore, $P = 2185\,\text{W}$

15. **C.** $353.44\,\text{W}$

Explanation: Total force needed for constant-speed climbing: $F = mg\sin 5° + 20 = 68.36 + 20$

So, $F = 88.36\,\text{N}$

Power, $P = Fv = 88.36 \times 4$

Therefore, $P \approx 353.44\,\text{W}$

16. **C.** $14970\,\text{W}$

Explanation: Mass flow rate, $\dot{m} = \varrho Av = 1000 \times 0.02 \times 3 = 60\,\text{kgs}^{-1}$

Power, $P = \dot{m}\left(gh + \frac{1}{2}v^2\right) = 60 \times (245 + 4.5)$

Therefore, $P = 60 \times 249.5 = 14970\,\text{W}$

17. **B.** $156,800\,\text{N}$

Explanation: Hammer's kinetic energy, $KE = mgh = 800 \times 9.8 \times 2 = 15680\,\text{J}$

Energy transferred to the pile (80%), $E = 0.8 \times 15680 = 12544\,\text{J}$

Resisting force, $F = \frac{E}{d} = \frac{12544}{0.08}$

Therefore, $F = 156800\,\text{N}$

18. **D.** $10.81\,\text{kms}^{-1}$

Explanation: Mars's gravity, $g_{Mars} = g_{Earth} \times \frac{W_{Mars}}{W_{Earth}} = 9.8 \times \frac{35}{47}$

So, $g_{Mars} \approx 7.298\,\text{ms}^{-2}$

Mars's radius, $R_{Mars} = 1.25 \times 6400 = 8000\,\text{km}$

Escape velocity, $v_{esc} = \sqrt{2g_{Mars}R_{Mars}} = \sqrt{2 \times 7.298 \times 8 \times 10^6}$

Therefore, $v_{esc} \approx 10.81\,\text{kms}^{-1}$

19. **D.** $10,210\,\text{s}$

Explanation: In a circular orbit, $KE = \frac{GMm}{2r} \Rightarrow r = \frac{GMm}{2 \times KE}$

Here, $GMm = 6.673 \times 10^{-11} \times 4 \times 10^{24} \times 800 \approx 2.135 \times 10^{17}$

So, $r = \frac{2.135 \times 10^{17}}{2 \times 1.2 \times 10^{10}} \approx 8.898 \times 10^6\,\text{m}$

Kepler's 3rd law: $T = 2\pi\sqrt{\frac{r^3}{GM}}$, with $GM \approx 2.669 \times 10^{14}$

$\frac{r^3}{GM} \approx 2.640 \times 10^6 \Rightarrow \sqrt{\frac{r^3}{GM}} \approx 1624.8$

Therefore, $T = 2\pi \times 1624.8 \approx 10,210\,\text{s} \approx 2.84$ hours

20. **A.** $5470\,\text{km}$

Explanation: At depth, $g_d = g\left(1 - \frac{x}{R}\right)$; at height (inverse square law), $g_h = \frac{gR^2}{(R+x)^2}$

According to the condition, $g\left(1 - \frac{x}{R}\right) = \frac{1}{2} \times \frac{gR^2}{(R+x)^2}$

Using calculator, $x \approx 5469\,\text{km}$

21. **D.** $2.8\,\text{ms}^{-1}$

Explanation: Effective gravity due to buoyancy, $g_{eff} = g\left(1 - \frac{\varrho_{water}}{\varrho_{bob}}\right) = 9.8(1 - 0.2)$
So, $g_{eff} = 7.84\,ms^{-2}$
At the horizontal extremes the bob is momentarily at rest ($v_{min} = 0$); it falls a height L to the bottom
From energy conservation, $v_{max}^2 = 2g_{eff}L = 2 \times 7.84 \times 0.5 = 7.84$
So, $v_{max} = 2.8\,ms^{-1}$
Therefore, the difference $= 2.8 - 0 = 2.8\,ms^{-1}$

22. **D.** $35,940\,km$
Explanation: $r^3 = \frac{gR^2T^2}{4\pi^2}$, with $T = 86400\,s$
This gives $r^3 \approx 7.588 \times 10^{22}$
So, $r \approx 4.234 \times 10^7\,m = 42,340\,km$
Therefore, $h = r - R = 42,340 - 6,400 = 35,940\,km$

23. **B.** $5098.4\,kgs^{-1}$
Explanation: $g_{eff} = g_0 - R\omega^2\cos^2\phi$ [From this equation at 30° latitude, $g \approx 9.807\,ms^{-2}$ is obtained, which is given in the question]
$$P = \dot{m}gh \Rightarrow \dot{m} = \frac{P}{gh}$$
$$\dot{m} = \frac{1{,}000{,}000}{9.807 \times 20} = \frac{1{,}000{,}000}{196.14}$$
Therefore, $\dot{m} \approx 5098.4\,kg\,s^{-1}$

24. **C.** $1837.5\,N$
Explanation: Required useful (output) work, $W_{out} = mgh = 1200 \times 9.8 \times 1.5 = 17,640\,J$
With 20% loss, actual input work, $W_{in} = \frac{17640}{0.8} = 22,050\,J$
Total displacement of the small piston, $d = 40 \times 0.30 = 12\,m$
Average force, $F = \frac{W_{in}}{d} = \frac{22050}{12}$
Therefore, $F = 1837.5\,N$

25. **C.** $36,411\,N$
Explanation: $v = gt = 9.8 \times 1.74 = 17.05\,m/s$ (velocity at the moment of impact)
Using $F - mg = \frac{mv^2}{2d}$, where $d = 0.03\,m$:
$$F = mg + \frac{mv^2}{2d}$$
$$F = 7.5(9.8) + \frac{7.5 \times (17.05)^2}{2 \times 0.03}$$
$$F = 73.5 + 36337.5$$
$$F \approx 3.64 \times 10^4\,N$$
Average resisting force of the soil $\approx 36{,}411\,N$

26. **B.** $6.25\,m$
Explanation: Stone's potential energy, $E_p = mgh = 5 \times 9.8 \times 15 = 735\,J$
Energy needed to break the object, $E = \frac{E_p}{4} = 183.75\,J$
So, the required height for the 3 kg stone, $h = \frac{E}{mg} = \frac{183.75}{3 \times 9.8}$
Therefore, $h = 6.25\,m$

27. **D.** $1.086\,MW$
Explanation: Water power, $P_{water} = \dot{m}gh = 2500 \times 9.8 \times 60 = 1,470,000\,W = 1.47\,MW$
Total output power, $P_{out} = P_{water} \times 0.82 \times 0.90$
Therefore, $P_{out} \approx 1.086\,MW$

28. **B.** $10.14\,s$
Explanation: Useful power, $P = 135 \times 0.72\,HP = 97.2\,HP = 97.2 \times 746 = 72511.2\,W$
Change in kinetic energy, $\Delta KE = \frac{1}{2}mv^2 = \frac{1}{2}(1200)(35)^2 = 735000\,J$
Minimum time, $t = \frac{\Delta KE}{P} = \frac{735000}{72511.2}$
Therefore, $t \approx 10.14\,s$

29. **D.** $499.14\,N$
Explanation: At the pole, rotation has no effect, so mass, $m = \frac{500}{9.8} \approx 51.02\,kg$
Decrease in g at latitude 45°, $\Delta g = \omega^2 R\cos^2 45° = (7.5 \times 10^{-5})^2 \times 6 \times 10^6 \times 0.5$
So, $\Delta g \approx 0.016875\,ms^{-2}$
Weight loss, $\Delta W = m\Delta g \approx 51.02 \times 0.016875 \approx 0.861\,N$
Therefore, apparent weight $= 500 - 0.861 \approx 499.14\,N$

30. **B.** $14939\,km$
Explanation: Initial distance from Earth's center, $r_0 = R + 1500\,km = 7900\,km$ and $v_0 = 8.0\,kms^{-1}$
From energy conservation, $\frac{1}{2}mv_0^2 - \frac{GMm}{r_0} = -\frac{GMm}{r_{max}}$
Using $GM = gR^2 = 9.8(6.4 \times 10^6)^2$, $r_{max} \approx 2.1339 \times 10^7\,m = 21339\,km$
So the maximum height above Earth's surface, $h_{max} = r_{max} - R \approx 21339 - 6400$
Therefore, $h_{max} \approx 14939\,km$

31. **C. It escapes the gravitational field and travels to infinity**

Explanation: First check the escape velocity:
$v_{esc} = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2\times6.673\times10^{-11}\times6.5\times10^{23}}{5\times10^{6}}}$
So, $v_{esc} \approx 4166\,ms^{-1}$
Effective speed after the 15% KE loss:
$\frac{1}{2}v_{eff}^2 = 0.85 \times \frac{1}{2}(5000)^2$
This gives $v_{eff} \approx 4610\,ms^{-1}$
Since $v_{eff}(4610) > v_{esc}(4166)$, the object still carries more than escape energy
Therefore, it does not stop at a finite height — it escapes the gravitational field to infinity

32. **A.** $3.13\,ms^{-1}$
Explanation: Energy released, $E = (m_1 - m_2)gd = (5-3)\times9.8\times2$
So, $E = 39.2\,J$
Total kinetic energy, $KE = \frac{1}{2}(m_1+m_2)v^2 = \frac{1}{2}(8)v^2 = 4v^2$
$4v^2 = 39.2 \Rightarrow v^2 = 9.8$
Therefore, $v \approx 3.13\,ms^{-1}$

33. **C.** $7.168\times10^9\,J$
Explanation: Total energy in a circular orbit, $E = -\frac{GMm}{2r}$, with $GM = gR^2 \approx 4.014\times10^{14}$
In the initial orbit, $E_1 = -\frac{GMm}{2\times7\times10^6} \approx -1.4336\times10^{10}\,J$
In the new orbit, $E_2 = -\frac{GMm}{2\times14\times10^6} \approx -7.168\times10^9\,J$
Required energy, $\Delta E = E_2 - E_1$
Therefore, $\Delta E \approx 7.168\times10^9\,J$ (energy must be added to raise the orbit)

34. **A.** $\frac{\pi G\varrho_0 R^2}{9}$
Explanation: Mass enclosed up to $r' = \frac{R}{3}$:
$M_{enc} = \int_0^{r'} 4\pi\varrho_0 r^3\,dr = \pi\varrho_0 r'^4$
So, $M_{enc} = \frac{\pi\varrho_0 R^4}{81}$
Gravitational field, $g\left(\frac{R}{3}\right) = \frac{GM_{enc}}{r'^2} = \frac{G\left(\frac{\pi\varrho_0R^4}{81}\right)}{\frac{R^2}{9}}$
Therefore, $g\left(\frac{R}{3}\right) = \frac{\pi G\varrho_0R^2}{9}$ (equivalently $\frac{GM}{9R^2}$, using total mass $M = \pi\varrho_0R^4$)

35. **D.** 0.548 : 1
Explanation: Since $v_{esc} = \sqrt{2gR}$ and $g \propto \varrho R$, we get $v_{esc} \propto R\sqrt{\varrho}$
So, $\frac{v_1}{v_2} = \frac{R_1}{R_2}\sqrt{\frac{\varrho_1}{\varrho_2}} = \frac{3}{5}\sqrt{\frac{5}{6}}$
Therefore, $\frac{v_1}{v_2} \approx 0.6\times0.9129 \approx 0.548$

36. **D.** 4 : 3
Explanation: Total energy in a circular orbit, $E = -\frac{GMm}{2r}$
For the first satellite, $E_1 = -\frac{GMm}{2r}$
For the second satellite, $E_2 = -\frac{GM(3m)}{2\times4r} = -\frac{3GMm}{8r}$
Ratio, $\frac{E_1}{E_2} = \frac{-GMm/2r}{-3GMm/8r} = \frac{1/2}{3/8}$
Therefore, $E_1 : E_2 = 4 : 3$

37. **C.** 5067 s
Explanation: $T = 2\pi\sqrt{\frac{R^3}{GM}}$ simplifies, in terms of density, to $T = \sqrt{\frac{3\pi}{G\varrho}}$ — independent of R!
Here, $T = \sqrt{\frac{3\pi}{6.673\times10^{-11}\times5500}} \approx \sqrt{2.567\times10^7}$
Therefore, $T \approx 5067\,s \approx 84.5$ minutes

38. **B.** $6289.5\,kgm^{-3}$
Explanation: Mass from escape velocity,
$M = \frac{v_{esc}^2R}{2G} = \frac{(15000)^2\times8\times10^6}{2\times6.673\times10^{-11}}$
So, $M \approx 1.3487\times10^{25}\,kg$
Density, $\varrho = \frac{M}{\frac{4}{3}\pi R^3}$
Therefore, $\varrho \approx 6289.5\,kgm^{-3}$

39. **C.** 2000 N
Explanation: Speed, $v = 108\,kmh^{-1} = 30\,ms^{-1}$
At constant speed, the applied force equals the resistive force: $F = \frac{P}{v} = \frac{60000}{30}$
Therefore, $F = 2000\,N$

40. **C.** 0.906 m
Explanation: Spring energy, $E_{sp} = \frac{1}{2}kx^2 = \frac{1}{2}(150)(0.1)^2$
So, $E_{sp} = 0.75\,J$
From energy conservation, the height gained, $h = \frac{E_{sp}}{mg} = \frac{0.75}{0.2\times9.8}$
So, $h \approx 0.3827\,m$
Distance along the ramp, $d = \frac{h}{\sin25^\circ} = \frac{0.3827}{0.4226}$
Therefore, $d \approx 0.906\,m$

41. **B.** $6.92\,ms^{-1}$
Explanation: From energy conservation over the compression ($x = 0.25\,m$):
$\frac{1}{2}mv^2 + mgx\sin37^\circ - \mu mgx\cos37^\circ = \frac{1}{2}kx^2$
Here, $0.25v^2 + 0.735 - 0.196 = 12.5$
$\Rightarrow v^2 = 47.844$
Therefore, $v \approx 6.92\,ms^{-1}$

42. **A.** $44,862\,\text{Nm}^{-1}$

Explanation: Total fall, $h + x = 5 + 0.15 = 5.15\,\text{m}$

From energy conservation, $mg(h + x) = \frac{1}{2}kx^2$

Here, $10 \times 9.8 \times 5.15 = \frac{1}{2}k(0.15)^2$

$504.7 = 0.01125k$

Therefore, $k \approx 44,862\,\text{Nm}^{-1}$

43. **B.** 141.9 HP

Explanation: Force needed for constant-velocity ascent, $F = mg + 0.2mg = 1.2mg = 1.2 \times 1500 \times 9.8$

So, $F = 17640\,\text{N}$

Power, $P = Fv = 17640 \times 6 = 105840\,\text{W}$

Therefore, $P = \frac{105840}{746} \approx 141.9\,\text{HP}$

44. **D.** 40 ft

Explanation: $g = \frac{4}{3}\pi G\varrho R \Rightarrow g \propto \varrho R$

So, $\frac{g_A}{g_B} = \frac{\varrho_A}{\varrho_B} \times \frac{R_A}{R_B} = 5 \times 4 = 20$

Since jump height (same energy) satisfies $h \propto \frac{1}{g}$

Therefore, $h_B = h_A \times \frac{g_A}{g_B} = 2 \times 20 = 40\,\text{ft}$

45. **C.** 2.23 : 1

Explanation: Semi-major axis, $a = \frac{r_p + r_a}{2} = \frac{0.4+40}{2} = 20.2\,\text{AU}$

Vis-viva equation: $v_p^2 = GM_{sun}\left(\frac{2}{r_p} - \frac{1}{a}\right) = GM_{sun}\left(\frac{2}{0.4} - \frac{1}{20.2}\right)$

So, $v_p^2 \approx 4.9505 \times GM_{sun}$

Earth's orbital speed ($r = 1\,\text{AU}$), $v_{Earth}^2 = GM_{sun}$

$\therefore \left(\frac{v_p}{v_{Earth}}\right)^2 = 4.9505$

Therefore, $\frac{v_p}{v_{Earth}} \approx 2.23$

46. **B.** $2.005 \times 10^{30}\,\text{kg}$

Explanation: $M = \frac{4\pi^2 r^3}{GT^2}$, with $T = 365.25 \times 24 \times 3600 = 3.156 \times 10^7\,\text{s}$

So, $M = \frac{39.478 \times (1.5 \times 10^{11})^3}{6.673 \times 10^{-11} \times (3.156 \times 10^7)^2}$

Therefore, $M \approx 2.005 \times 10^{30}\,\text{kg}$

47. **D.** 7140 J

Explanation: Velocity, $v(t) = \frac{dx}{dt} = 5 - 6t^2 + 14t$

$v(2.5) = 5 - 37.5 + 35 = 2.5\,\text{ms}^{-1}$

$v(4.5) = 5 - 121.5 + 63 = -53.5\,\text{ms}^{-1}$

By the work-energy theorem, $W = \Delta KE = \frac{1}{2}m(v_2^2 - v_1^2) = \frac{1}{2}(5)(2862.25 - 6.25)$

Therefore, $W = 7140\,\text{J}$

48. **C. KE increases, PE decreases, Total E decreases**

Explanation: $KE = \frac{GMm}{2r}$, $PE = -\frac{GMm}{r}$, $E = -\frac{GMm}{2r}$

As r decreases, KE increases (satellite speeds up)

PE becomes more negative (decreases)

Therefore, E also becomes more negative (decreases) — even though KE is increasing, this is a well-known orbital-mechanics result

49. **A.** 1.155 : 1

Explanation: $v = \sqrt{2gR} = \sqrt{\frac{8}{3}\pi G\varrho R^2} \Rightarrow \frac{v_X}{v_E} = \frac{R_X}{R_E}\sqrt{\frac{\varrho_X}{\varrho_E}}$

$\frac{v_X}{v_E} = 1.5 \times \sqrt{\frac{16}{27}} = \frac{3}{2} \times \frac{4}{3\sqrt{3}} = \frac{2}{\sqrt{3}}$

Therefore, $v_X : v_E = 2\sqrt{3} : 3 \approx 1.155 : 1$

50. **B.** 1.314 HP

Explanation: Mass flow rate, $\dot{m} = \frac{200}{60} \approx 3.333\,\text{kgs}^{-1}$

Useful power, $P_{use} = \dot{m}gh = 3.333 \times 9.8 \times 18$

So, $P_{use} \approx 587.98\,\text{W}$

Input power, $P_{in} = \frac{P_{use}}{0.6} \approx 979.97\,\text{W}$

Therefore, $P_{in} = \frac{979.97}{746} \approx 1.314\,\text{HP}$