1. $P = F/A$, so $F = PA = 10^5 10^{-2}$ [N m^2] $= 10^3$ [N]
2. $F = PA = \int_A dA\ P = 10^{-2} \int_0^{0.1} dx\ [10^5 + 10^3 x] = 100.05$ [N]
3. $F = PA = \int_A dA\ P = \int_{-0.05}^{0.05} dx \int_{-0.05}^{0.05} dy\ [10^5 + 10^3 \cos(2\pi x/0.1)\cos(2\pi y/0.1)] = 10^3$ [N]
4. $P = P_0 + \rho g h = 10^5 + 10^3 \cdot 10 \cdot 3 = 1.3 \times 10^5$ [Pa] $= 1.3$ [bar]
5. N/A
6. The pressure difference between heights is equal to the pressure difference between the inside of the dewar and the atmosphere, so 4.05×10^5 [Pa] $= \rho g h = 13.5 \cdot 10^3 \cdot 10h$, so $h = 3$ [m]
7. $F = F_g + F_b = -m_d g + m_w g = -\rho_d V g + \rho_w V g = (\rho_w - \rho_d) V g$. $\rho_w - \rho_d > 0$, so upwards.
8. $y(t) = (\rho_w - \rho_d) g t^2/2 + v_0 t + y_0 = g t^2/2$. $y(t^*) = 20$, so $t^* = 5.16$ [s].
9. $A_{\text{in}} v_{\text{in}} = A_{\text{out}} v_{\text{out}}$, so $v_{\text{out}} = 1000$ [m/s]
10. This is in general hard, so we assume that the engine does all of its work at $r = 0.5$ [m], in which case the air is moving 40 [m/s] already, then the work speeds it as $1000 = (v^2 - 40^2)^2/2$, or to $v = 60$, so the output speed is 1500 [m/s].
11. The area of the tube is 5.07×10^{-4} [m^2], so summing the flow rates, we find $v = \dot{V}/A = 0.4012$ [m/s]

$$\dot{V}_{H_2O_2} = \frac{1 \text{ mol } H_2O_2}{1 \text{ sec}} \cdot \frac{0.034 \text{ kg } H_2O_2}{1 \text{ mol } H_2O_2} \cdot \frac{1 \text{ m}^3 \text{ } H_2O_2}{1450 \text{ kg } H_2O_2} = 2.34 \times 10^{-5} \ \frac{\text{m}^3}{\text{sec}}$$

$$\dot{V}_{H_2O} = \frac{10 \text{ mol } H_2O}{1 \text{ sec}} \cdot \frac{0.018 \text{ kg } H_2O}{1 \text{ mol } H_2O} \cdot \frac{1 \text{ m}^3 \text{ } H_2O}{1000 \text{ kg } H_2O} = 18 \times 10^{-5} \ \frac{\text{m}^3}{\text{sec}}$$

12. The flow rate is now 21.6×10^{-5} [m^3/s] so it moves at a velocity of 0.4260 [m/s]
13. $P_i + \rho g y_i + \rho v_i^2/2 = P_f + \rho g y_f + \rho v_f^2/2$, here $g y_i + v_i^2/2 = g y_f + v_f^2/2$, or with values, $v_f = 43.4$ [m/s]
14. We need to add another energy term, so: $P_i + \rho g y_i + \rho v_i^2/2 = P_f + \rho g y_f + \rho v_f^2/2 + E/[\text{m}^3]$, or $E/[\text{m}^3] = \rho g y_i + \rho v_i^2/2 - \rho g y_f - \rho v_f^2/2$, and $\dot{V} = Av$, so the power is $E\dot{V}/[\text{m}^3] = 6.21 \times 10^6$ [W]
15. We are told:

$$F_{\text{net}} = F_{\text{buoyancy}} + F_{\text{gravity}} + F_{\text{drag}}$$

So by Newton's Law:

$$m_s a = m_f g - m_s g - 6\pi\mu r v$$

Which is:

$$\left[\frac{4}{3}\pi r^3 \rho_s\right] \ddot{y} + [6\pi\mu r]\,\dot{y} + [0] y = \left[\frac{4}{3}\pi r^3 g(\rho_f - \rho_s)\right]$$

The roots of the characteristic equation are:

$$\lambda_\pm = \frac{-6\pi\mu r \pm \sqrt{(6\pi\mu r)^2 - 4\frac{4}{3}\pi r^3 \rho_s 0}}{2\frac{4}{3}\pi r^3 \rho_s} = -\frac{9\mu}{2r^2\rho_s};\ 0$$

Now we seek a solution to the inhomogeneous equation with form At, so:

$$\left[\frac{4}{3}\pi r^3 \rho_s\right] 0 + [6\pi\mu r]\, A + [0] A t = \left[\frac{4}{3}\pi r^3 g(\rho_f - \rho_s)\right] \quad \Longleftrightarrow \quad A = \frac{4r^2 g(\rho_f - \rho_s)}{18\mu}$$

We now apply the boundary conditions:

$$y(0) = 0 = \alpha_+ + \alpha_-$$
$$\dot{y}(0) = 0 = \alpha_+\lambda_+ + \alpha_-\lambda_- + A$$

So we find:

$$y(t) = y_h(t) + y_p(t) = \frac{4r^4 g(\rho_f - \rho_s)}{81\mu^2}\left[\exp\left(-\frac{9\mu}{2r^2\rho_s}t\right) - 1\right] + \frac{4r^2 g(\rho_f - \rho_s)}{18\mu} t$$