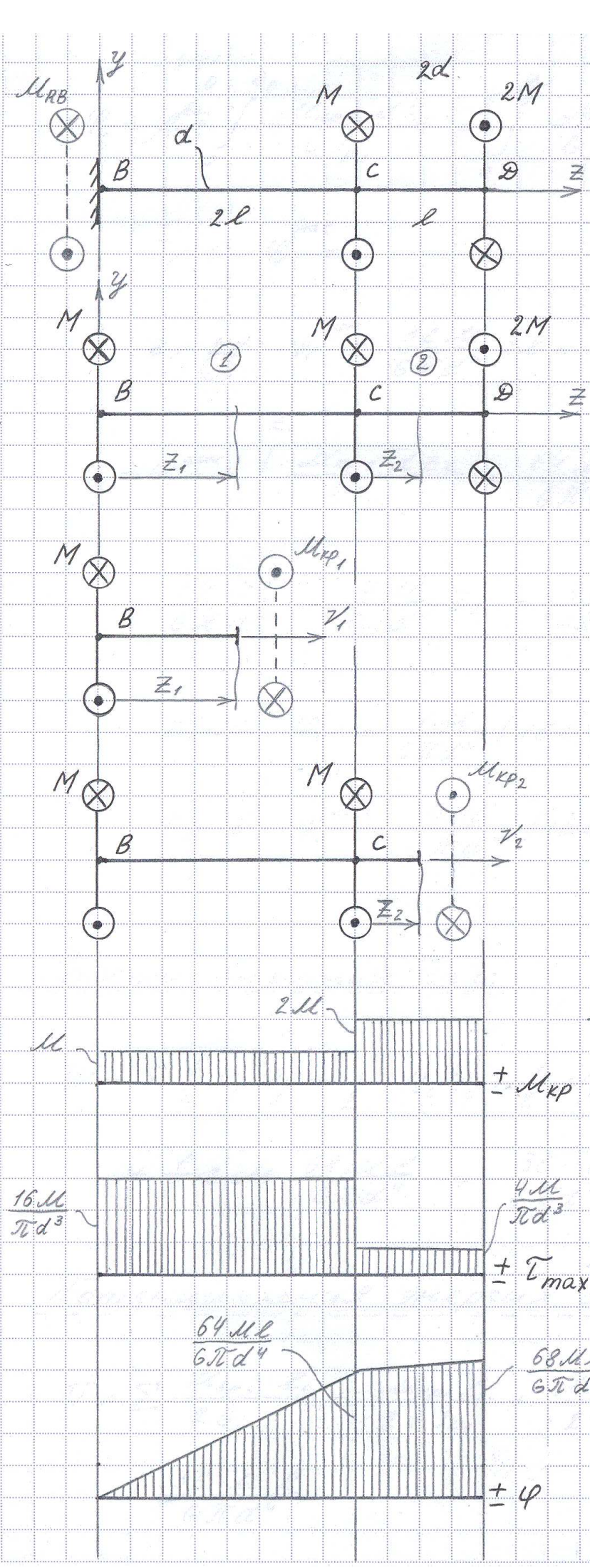

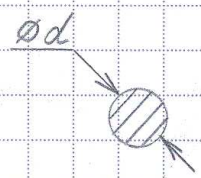

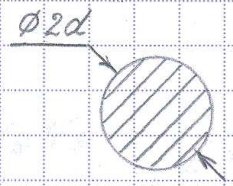

Дано: $G, l, M, d, [\tau_T]$

Найти: $M_{кр}, \tau_{max}, \varphi, \eta, W, U$.

$$\sum M_z = 0 = -M_{RB} - M + 2M$$

$$M_{RB} = M$$

$$\sum M_{z_1} = 0 = -M + M_{кр1} \Rightarrow M_{кр1} = M$$

$$\sum M_{z_2} = 0 = -M - M + M_{кр2}$$

$$M_{кр2} = 2M$$

$$J_{p1} = \frac{\pi d^4}{32}$$

$$W_{p1} = \frac{\pi d^3}{16}$$

$$J_{p2} = \frac{\pi (2d)^4}{32} = \frac{\pi d^4}{2}$$

$$W_{p2} = \frac{\pi (2d)^3}{16} = \frac{\pi d^3}{2}$$

$$\tau_{max_1} = \frac{M_{кр1}}{W_{p1}} = \frac{M \cdot 16}{\pi d^3}$$

$$\tau_{max_2} = \frac{M_{кр2}}{W_{p2}} = \frac{2M \cdot 2}{\pi d^3} =$$

$$= \frac{4M}{\pi d^3}$$

$$\varphi_1 = \overset{\text{заделка}}{\varphi_0^{\text{кон}}} + \int_0^{z_1} \frac{M_{кр1}\, dz_1}{G_1 J_{p1}} = \int_0^{z_1} \frac{M \cdot 32}{G \pi d^4}\, dz_1 = \frac{M \cdot 32}{G\pi d^4} \int_0^{z_1} dz_1 = \frac{32M}{G\pi d^4} z_1$$

$$z_1 = 0 \cdot \quad \varphi_1^{\text{нач}} = 0$$

$$z_1 = 2\ell \cdot \quad \varphi_1^{\text{кон}} = \frac{32M}{G\pi d^4} 2\ell = \frac{64M\ell}{G\pi d^4}$$

$$\varphi_2 = \varphi_1^{\text{кон}} + \int_0^{z_2} \frac{M_{кр2}\, dz_2}{G_2 J_{p2}} = \frac{64M\ell}{G\pi d^4} + \int_0^{z_2} \frac{2 \cdot M \cdot 2}{G\pi d^4}\, dz_2 =$$

$$= \frac{64M\ell}{G\pi d^4} + \frac{4M}{G\pi d^4} z_2 = \frac{4M}{G\pi d^4} \cdot (16\ell + z_2)$$

$$z_2 = 0 \cdot \quad \varphi_2^{\text{нач}} = \frac{4M}{G\pi d^4}(16\ell + 0) = \frac{64M\ell}{G\pi d^4}$$

$$z_2 = \ell \cdot \quad \varphi_2^{\text{кон}} = \frac{4M}{G\pi d^4}(16\ell + \ell) = \frac{68M\ell}{G\pi d^4}$$

Работа внешних сил:

$$W = \sum \frac{1}{2} M_j \cdot \varphi_j = \frac{1}{2} M_c \varphi_c + \frac{1}{2} M_д \varphi_д = \frac{1}{2}(-M) \overset{32}{\frac{64M\ell}{G\pi d^4}} +$$

$$+ \frac{1}{2} 2M \frac{68M\ell}{G\pi d^4} = \frac{36 \cdot M^2 \ell}{G\pi d^4}$$

Потенциальная энергия системы:

$$U = \sum \frac{M_{кр i}^2 \cdot \ell_i}{2 G_i J_{p i}} = \frac{M_{кр1}^2 \ell_1}{2 G_1 J_{p1}} + \frac{M_{кр2}^2 \ell_2}{2 G_2 J_{p2}} = \frac{M^2 2\ell \cdot 32}{2 G\pi d^4} + \frac{(2M)^2 \ell \cdot 2}{2 G\pi d^4} =$$

$$= \frac{36 M^2 \ell}{G\pi d^4}$$

$$W = U \quad \nabla$$

Коэффициент запаса прочности:

$$\eta = \frac{\tau_T}{|\tau_{max}|_{max}} = \frac{\tau_T \pi d^3}{16 \cdot M} \qquad \left[\frac{\frac{H}{M^2} \cdot M^3}{H \cdot M} \right] = [\ ]$$

$$|\tau_{max}|_{max} = max\left(|\tau_{max_1}|, |\tau_{max_2}| \right) =$$

$$= max\left(\frac{16M}{\pi d^3}, \frac{4M}{\pi d^3} \right) = \frac{16M}{\pi d^3}$$