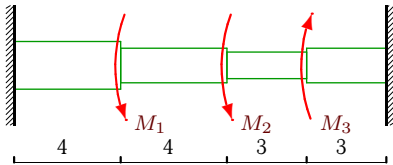


## Кручение стержней кругового сечения

Найти моменты заделок опор стального стержня кусочно-постоянного круглого сечения. К стержню приложены моменты  $M_1$ ,  $M_2$ ,  $M_3$ . Построить эпюры углов закручивания. Модуль сдвига материала  $G = 80 \text{ ГПа}$ . Длины участков даны в м.

**Задача 18.1.**

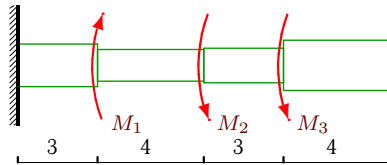
2



$$M_1 = 52 \text{ кНм}, M_2 = 18 \text{ кНм}, M_3 = 36 \text{ кНм}, d_1 = 0.18 \text{ м}, d_2 = 0.13 \text{ м}, d_3 = 0.1 \text{ м}, d_4 = 0.13 \text{ м}.$$

**Задача 18.2.**

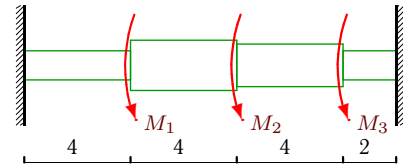
2



$$M_1 = 14 \text{ кНм}, M_2 = 40 \text{ кНм}, M_3 = 7 \text{ кНм}, d_1 = 0.16 \text{ м}, d_2 = 0.12 \text{ м}, d_3 = 0.13 \text{ м}, d_4 = 0.19 \text{ м}.$$

**Задача 18.3.**

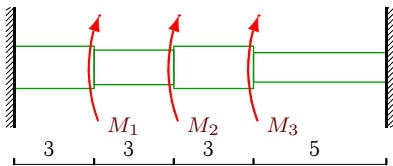
2



$$M_1 = 65 \text{ кНм}, M_2 = 36 \text{ кНм}, M_3 = 30 \text{ кНм}, d_1 = 0.11 \text{ м}, d_2 = 0.19 \text{ м}, d_3 = 0.16 \text{ м}, d_4 = 0.11 \text{ м}.$$

**Задача 18.4.**

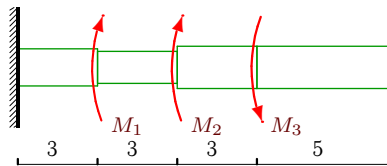
2



$$M_1 = 21 \text{ кНм}, M_2 = 21 \text{ кНм}, M_3 = 27 \text{ кНм}, d_1 = 0.16 \text{ м}, d_2 = 0.13 \text{ м}, d_3 = 0.16 \text{ м}, d_4 = 0.11 \text{ м}.$$

**Задача 18.5.**

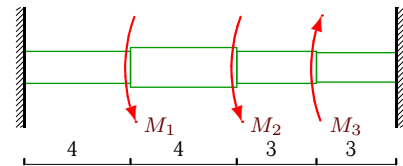
2



$$M_1 = 18 \text{ кНм}, M_2 = 40 \text{ кНм}, M_3 = 7 \text{ кНм}, d_1 = 0.14 \text{ м}, d_2 = 0.12 \text{ м}, d_3 = 0.16 \text{ м}, d_4 = 0.16 \text{ м}.$$

**Задача 18.6.**

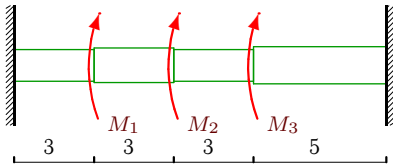
2



$$M_1 = 30 \text{ кНм}, M_2 = 30 \text{ кНм}, M_3 = 28 \text{ кНм}, d_1 = 0.12 \text{ м}, d_2 = 0.15 \text{ м}, d_3 = 0.12 \text{ м}, d_4 = 0.11 \text{ м}.$$

**Задача 18.7.**

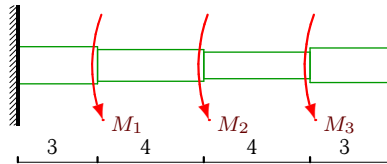
2



$$M_1 = 24 \text{ кНм}, M_2 = 12 \text{ кНм}, M_3 = 60 \text{ кНм}, d_1 = 0.12 \text{ м}, d_2 = 0.13 \text{ м}, d_3 = 0.12 \text{ м}, d_4 = 0.14 \text{ м}.$$

**Задача 18.8.**

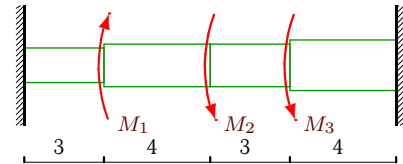
2



$$M_1 = 7 \text{ кНм}, M_2 = 60 \text{ кНм}, M_3 = 26 \text{ кНм}, d_1 = 0.14 \text{ м}, d_2 = 0.12 \text{ м}, d_3 = 0.1 \text{ м}, d_4 = 0.13 \text{ м}.$$

**Задача 18.9.**

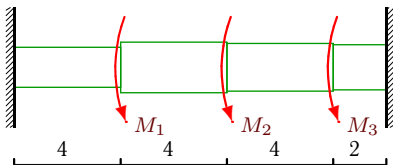
2



$$M_1 = 13 \text{ кНм}, M_2 = 30 \text{ кНм}, M_3 = 7 \text{ кНм}, d_1 = 0.13 \text{ м}, d_2 = 0.16 \text{ м}, d_3 = 0.16 \text{ м}, d_4 = 0.19 \text{ м}.$$

**Задача 18.10.**

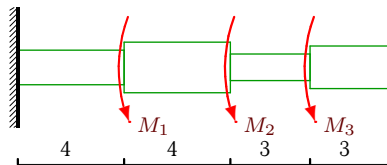
2



$$M_1 = 65 \text{ кНм}, M_2 = 36 \text{ кНм}, M_3 = 14 \text{ кНм}, d_1 = 0.15 \text{ м}, d_2 = 0.19 \text{ м}, d_3 = 0.18 \text{ м}, d_4 = 0.17 \text{ м}.$$

**Задача 18.11.**

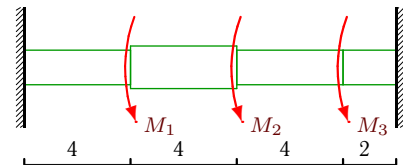
2



$$M_1 = 42 \text{ кНм}, M_2 = 40 \text{ кНм}, M_3 = 7 \text{ кНм}, d_1 = 0.13 \text{ м}, d_2 = 0.19 \text{ м}, d_3 = 0.1 \text{ м}, d_4 = 0.16 \text{ м}.$$

**Задача 18.12.**

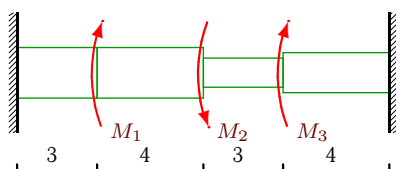
2



$$M_1 = 24 \text{ кНм}, M_2 = 26 \text{ кНм}, M_3 = 39 \text{ кНм}, d_1 = 0.13 \text{ м}, d_2 = 0.16 \text{ м}, d_3 = 0.13 \text{ м}, d_4 = 0.13 \text{ м}.$$

**Задача 18.13.**

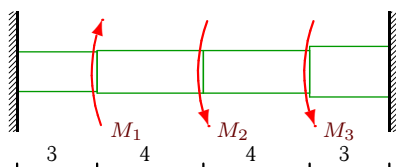
2



$M_1 = 15\text{кНм}$ ,  $M_2 = 35\text{кНм}$ ,  
 $M_3 = 30\text{кНм}$ ,  $d_1 = 0.19\text{м}$ ,  
 $d_2 = 0.19\text{м}$ ,  $d_3 = 0.11\text{м}$ ,  
 $d_4 = 0.15\text{м}$ .

**Задача 18.16.**

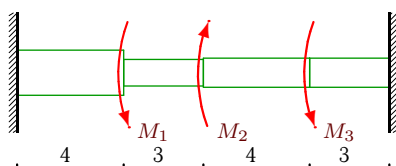
2



$M_1 = 28\text{кНм}$ ,  $M_2 = 60\text{кНм}$ ,  
 $M_3 = 40\text{кНм}$ ,  $d_1 = 0.15\text{м}$ ,  
 $d_2 = 0.16\text{м}$ ,  $d_3 = 0.16\text{м}$ ,  
 $d_4 = 0.19\text{м}$ .

**Задача 18.19.**

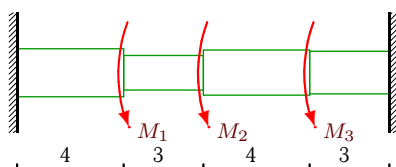
2



$M_1 = 32\text{кНм}$ ,  $M_2 = 28\text{кНм}$ ,  
 $M_3 = 56\text{кНм}$ ,  $d_1 = 0.17\text{м}$ ,  
 $d_2 = 0.1\text{м}$ ,  $d_3 = 0.11\text{м}$ ,  
 $d_4 = 0.11\text{м}$ .

**Задача 18.22.**

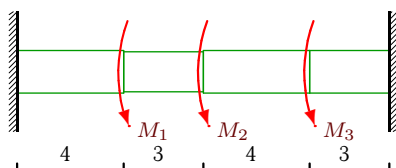
2



$M_1 = 30\text{кНм}$ ,  $M_2 = 7\text{кНм}$ ,  
 $M_3 = 18\text{кНм}$ ,  $d_1 = 0.18\text{м}$ ,  
 $d_2 = 0.13\text{м}$ ,  $d_3 = 0.17\text{м}$ ,  
 $d_4 = 0.16\text{м}$ .

**Задача 18.25.**

2



$M_1 = 50\text{кНм}$ ,  $M_2 = 7\text{кНм}$ ,  
 $M_3 = 9\text{кНм}$ ,  $d_1 = 0.16\text{м}$ ,  
 $d_2 = 0.15\text{м}$ ,  $d_3 = 0.16\text{м}$ ,  
 $d_4 = 0.16\text{м}$ .

**Задача 18.14.**

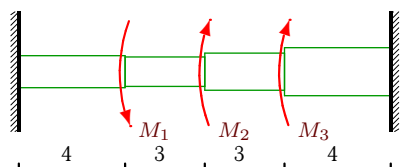
2



$M_1 = 14\text{кНм}$ ,  $M_2 = 28\text{кНм}$ ,  
 $M_3 = 27\text{кНм}$ ,  $d_1 = 0.14\text{м}$ ,  
 $d_2 = 0.15\text{м}$ ,  $d_3 = 0.18\text{м}$ ,  
 $d_4 = 0.19\text{м}$ .

**Задача 18.17.**

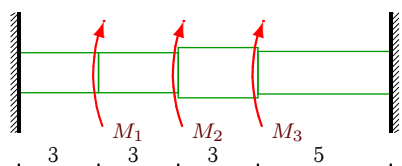
2



$M_1 = 30\text{кНм}$ ,  $M_2 = 28\text{кНм}$ ,  
 $M_3 = 30\text{кНм}$ ,  $d_1 = 0.12\text{м}$ ,  
 $d_2 = 0.11\text{м}$ ,  $d_3 = 0.14\text{м}$ ,  
 $d_4 = 0.18\text{м}$ .

**Задача 18.20.**

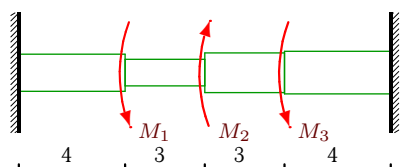
2



$M_1 = 18\text{кНм}$ ,  $M_2 = 32\text{кНм}$ ,  
 $M_3 = 30\text{кНм}$ ,  $d_1 = 0.15\text{м}$ ,  
 $d_2 = 0.15\text{м}$ ,  $d_3 = 0.19\text{м}$ ,  
 $d_4 = 0.16\text{м}$ .

**Задача 18.23.**

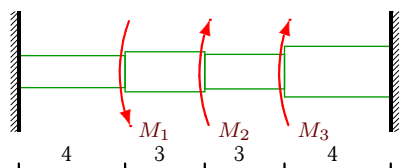
2



$M_1 = 16\text{кНм}$ ,  $M_2 = 20\text{кНм}$ ,  
 $M_3 = 7\text{кНм}$ ,  $d_1 = 0.14\text{м}$ ,  
 $d_2 = 0.1\text{м}$ ,  $d_3 = 0.15\text{м}$ ,  
 $d_4 = 0.16\text{м}$ .

**Задача 18.26.**

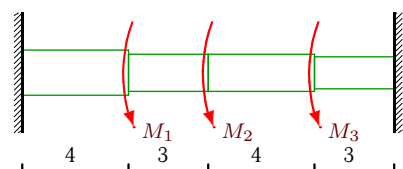
2



$M_1 = 14\text{кНм}$ ,  $M_2 = 18\text{кНм}$ ,  
 $M_3 = 24\text{кНм}$ ,  $d_1 = 0.12\text{м}$ ,  
 $d_2 = 0.15\text{м}$ ,  $d_3 = 0.13\text{м}$ ,  
 $d_4 = 0.19\text{м}$ .

**Задача 18.15.**

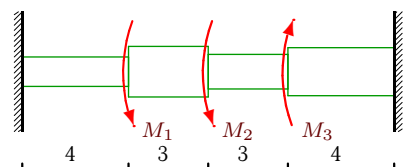
2



$M_1 = 50\text{кНм}$ ,  $M_2 = 7\text{кНм}$ ,  
 $M_3 = 33\text{кНм}$ ,  $d_1 = 0.17\text{м}$ ,  
 $d_2 = 0.14\text{м}$ ,  $d_3 = 0.14\text{м}$ ,  
 $d_4 = 0.12\text{м}$ .

**Задача 18.18.**

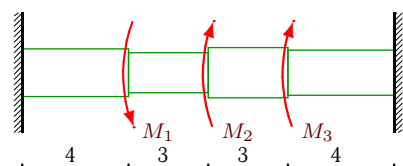
2



$M_1 = 40\text{кНм}$ ,  $M_2 = 7\text{кНм}$ ,  
 $M_3 = 6\text{кНм}$ ,  $d_1 = 0.11\text{м}$ ,  
 $d_2 = 0.19\text{м}$ ,  $d_3 = 0.13\text{м}$ ,  
 $d_4 = 0.18\text{м}$ .

**Задача 18.21.**

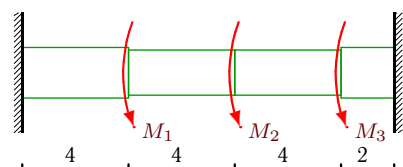
2



$M_1 = 16\text{кНм}$ ,  $M_2 = 12\text{кНм}$ ,  
 $M_3 = 44\text{кНм}$ ,  $d_1 = 0.18\text{м}$ ,  
 $d_2 = 0.15\text{м}$ ,  $d_3 = 0.19\text{м}$ ,  
 $d_4 = 0.17\text{м}$ .

**Задача 18.24.**

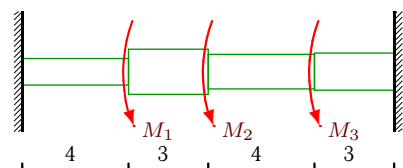
2



$M_1 = 22\text{кНм}$ ,  $M_2 = 15\text{кНм}$ ,  
 $M_3 = 55\text{кНм}$ ,  $d_1 = 0.19\text{м}$ ,  
 $d_2 = 0.17\text{м}$ ,  $d_3 = 0.17\text{м}$ ,  
 $d_4 = 0.19\text{м}$ .

**Задача 18.27.**

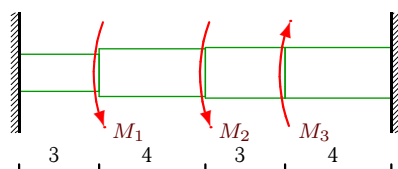
2



$M_1 = 50\text{кНм}$ ,  $M_2 = 7\text{кНм}$ ,  
 $M_3 = 8\text{кНм}$ ,  $d_1 = 0.1\text{м}$ ,  
 $d_2 = 0.17\text{м}$ ,  $d_3 = 0.13\text{м}$ ,  
 $d_4 = 0.14\text{м}$ .

**Задача 18.28.**

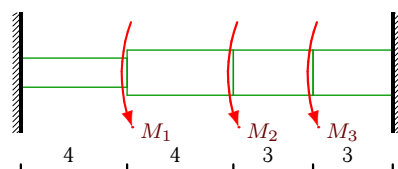
2



$M_1 = 7\text{кНм}$ ,  $M_2 = 45\text{кНм}$ ,  
 $M_3 = 12\text{кНм}$ ,  $d_1 = 0.14\text{м}$ ,  
 $d_2 = 0.18\text{м}$ ,  $d_3 = 0.19\text{м}$ ,  
 $d_4 = 0.19\text{м}$ .

**Задача 18.29.**

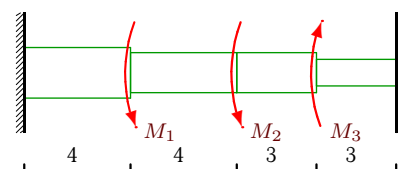
2



$M_1 = 55\text{кНм}$ ,  $M_2 = 10\text{кНм}$ ,  
 $M_3 = 7\text{кНм}$ ,  $d_1 = 0.11\text{м}$ ,  
 $d_2 = 0.17\text{м}$ ,  $d_3 = 0.17\text{м}$ ,  
 $d_4 = 0.17\text{м}$ .

**Задача 18.30.**

2



$M_1 = 45\text{кНм}$ ,  $M_2 = 45\text{кНм}$ ,  
 $M_3 = 15\text{кНм}$ ,  $d_1 = 0.19\text{м}$ ,  
 $d_2 = 0.15\text{м}$ ,  $d_3 = 0.15\text{м}$ ,  
 $d_4 = 0.1\text{м}$ .

**Кручение стержней кругового сечения**

№	$M_A$	$\varphi_1$	$\varphi_2$	$\varphi_3$
	кНм			
1	54.620	-2.650	-3.117	2.758
2	2.786	-0.162	-4.285	-1.181
3	51.949	-18.071	-17.561	-13.749
4	-51.463	3.000	7.074	7.625
5	-26.535	2.638	4.211	2.377
6	28.332	-6.958	-6.791	-0.957
7	-38.555	7.102	9.049	9.520
8	48.863	-4.858	-15.140	-5.903
9	2.974	-0.398	-1.639	-0.822
10	50.056	-5.036	-4.452	-1.980
11	58.010	-10.344	-10.970	-1.806
12	35.751	-6.375	-7.288	-4.748
13	8.434	-0.247	-1.163	1.854
14	11.297	-1.498	-1.226	-0.109
15	60.996	-3.719	-4.813	-5.343
16	9.306	-0.702	-3.601	-1.838
17	10.188	-2.502	2.667	1.853
18	16.888	-5.874	-5.197	-1.170
19	27.829	-1.697	-0.104	-8.393
20	-38.200	2.882	4.406	4.060
21	-5.203	0.252	1.852	2.122
22	31.421	-1.524	-1.714	-1.374
23	9.050	-1.200	1.455	0.470
24	29.879	-1.168	-1.648	-1.214
25	41.669	-3.238	-2.610	-1.418
26	-1.160	0.285	1.429	1.049
27	22.712	-11.567	-10.319	-4.205
28	15.841	-1.575	-2.004	-0.944
29	19.227	-6.688	-4.507	-2.413
30	66.932	-2.616	-4.822	-3.082