

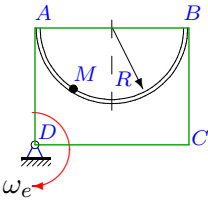
## Сложное движение точки, плоская траектория

Геометрическая фигура вращается вокруг оси, перпендикулярной ее плоскости. По каналу, расположенному на фигуре, движется точка  $M$  по известному закону  $\sigma(t)$ . Найти абсолютную скорость и абсолютное ускорение точки при  $t = t_1$ . Даны функция  $\sigma(t)$ , закон вращения фигуры  $\varphi_e(t)$  (или постоянная угловая скорость  $\omega_e$ ), время  $t_1$  и размеры фигуры.  $BM$  или  $AM$  — длина отрезка прямой или дуги окружности.

Кирсанов М.Н. **Решбник. Теоретическая механика**/Под ред. А. И. Кириллова. — М.: ФИЗМАТЛИТ, 2002. — 384 с. (с.195.)

**Задача 10.1.** 9

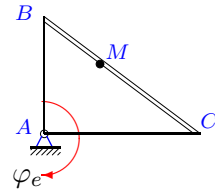
$\sigma(t) = AM = \frac{2\pi}{3}(t^3 + 4)$  см.



$\omega_e = 1.21$  рад/с,  
 $R = 31$  см,  
 $AD = 33$  см,  
 $t_1 = 3$  с.

**Задача 10.2.** 9

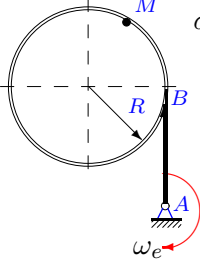
$\sigma(t) = BM = \frac{5}{6}(t^2 + 6t)$  см.



$\varphi_e = 0.08t^2$ ,  
 $AB = 14$  см,  
 $AC = 24$  см,  
 $t_1 = 3$  с.

**Задача 10.3.** 9

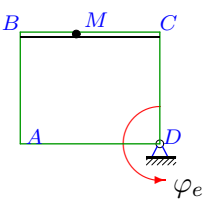
$\sigma(t) = BM = \frac{3\pi}{4}(t^2 + 4)t$  см.



$\omega_e = 0.75$  рад/с,  
 $R = 39$  см,  
 $AB = 44$  см,  
 $t_1 = 3$  с.

**Задача 10.4.** 9

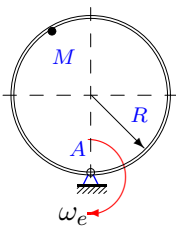
$\sigma(t) = BM = \frac{3}{4}(t^2 + 51)$  см.



$\varphi_e = 0.02t^2$ ,  
 $AB = 28$  см,  
 $BC = 55$  см,  
 $t_1 = 2$  с.

**Задача 10.5.** 9

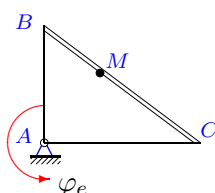
$\sigma(t) = AM = \frac{3\pi}{4}(t^3 + 2)$  см.



$\omega_e = 1.28$  рад/с,  
 $R = 3$  см,  
 $t_1 = 1$  с.

**Задача 10.6.** 9

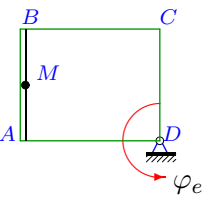
$\sigma(t) = BM = \frac{1}{6}(t^2 + 3)t$  см.



$\varphi_e = 0.1t^2$ ,  
 $AB = 7$  см,  
 $AC = 13$  см,  
 $t_1 = 2$  с.

**Задача 10.7.** 9

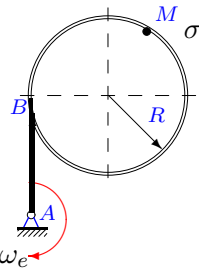
$\sigma(t) = AM = \frac{5}{6}(t^2 + 6t)$  см.



$\varphi_e = 0.05t^2$ ,  
 $AB = 27$  см,  
 $BC = 29$  см,  
 $t_1 = 3$  с.

**Задача 10.8.** 9

$\sigma(t) = BM = \frac{3\pi}{4}(t^3 + 4)$  см.

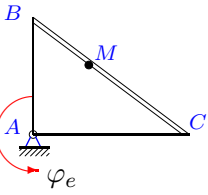


$\omega_e = 0.81$  рад/с,  
 $R = 31$  см,  
 $AB = 36$  см,  
 $t_1 = 3$  с.

**Задача 10.9.**

9

$$\sigma(t) = BM = \frac{1}{2}(t^2 + 51) \text{ см.}$$

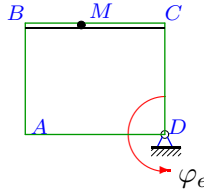


$$\begin{aligned} \varphi_e &= 0.02t^2, \\ AB &= 28 \text{ см,} \\ AC &= 49 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.10.**

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$$\sigma(t) = BM = \frac{1}{3}(t^3 + 3) \text{ см.}$$

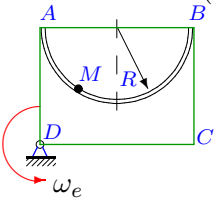


$$\begin{aligned} \varphi_e &= 0.11t^2, \\ AB &= 6 \text{ см,} \\ BC &= 11 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.11.**

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$$\sigma(t) = AM = \frac{2\pi}{3}(t^2 + 3)t \text{ см.}$$

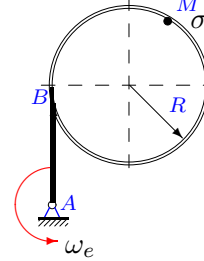


$$\begin{aligned} \omega_e &= 1.47 \text{ рад/с,} \\ R &= 14 \text{ см,} \\ AD &= 16 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.12.**

9

$$\sigma(t) = BM = \frac{4\pi}{3}(t^2 + 50) \text{ см.}$$

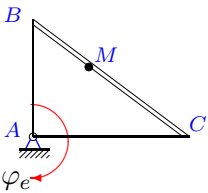


$$\begin{aligned} \omega_e &= 0.11 \text{ рад/с,} \\ R &= 51 \text{ см,} \\ AB &= 56 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.13.**

9

$$\sigma(t) = BM = \frac{2}{3}(t^2 + 3)t \text{ см.}$$

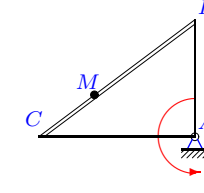


$$\begin{aligned} \varphi_e &= 0.29t^2, \\ AB &= 7 \text{ см,} \\ AC &= 13 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.14.**

9

$$\sigma(t) = BM = \frac{5}{6}(t^2 + 50) \text{ см.}$$

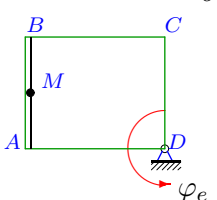


$$\begin{aligned} \varphi_e &= 0.02t^2, \\ AB &= 26 \text{ см,} \\ AC &= 45 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.15.**

9

$$\sigma(t) = AM = \frac{1}{4}(t^2 + 2t) \text{ см.}$$

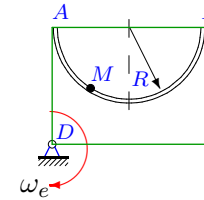


$$\begin{aligned} \varphi_e &= 0.1t^2, \\ AB &= 3 \text{ см,} \\ BC &= 5 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.16.**

9

$$\sigma(t) = AM = \frac{\pi}{3}(t^2 + 52) \text{ см.}$$

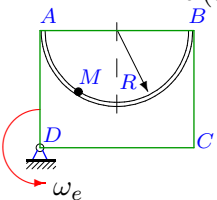


$$\begin{aligned} \omega_e &= 0.2 \text{ рад/с,} \\ R &= 61 \text{ см,} \\ AD &= 63 \text{ см,} \\ t_1 &= 3 \text{ с.} \end{aligned}$$

**Задача 10.17.**

9

$$\sigma(t) = AM = \frac{3\pi}{4}(t^2 + 3)t \text{ см.}$$

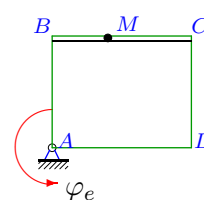


$$\begin{aligned} \omega_e &= 1.43 \text{ рад/с,} \\ R &= 14 \text{ см,} \\ AD &= 16 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.18.**

9

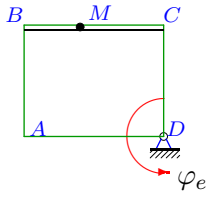
$$\sigma(t) = BM = \frac{3}{4}(t^3 + 2) \text{ см.}$$



$$\begin{aligned} \varphi_e &= 0.37t^2, \\ AB &= 2 \text{ см,} \\ BC &= 3 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.19.**

9

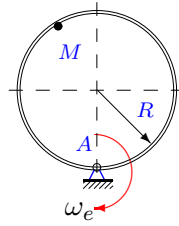


$$\sigma(t) = BM = \frac{2}{3}(t^2 + 50) \text{ см.}$$

$$\begin{aligned} \varphi_e &= 0.02t^2, \\ AB &= 26 \text{ см,} \\ BC &= 51 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.20.**

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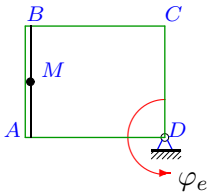


$$\sigma(t) = AM = \frac{4\pi}{3}(t^3 + 2) \text{ см.}$$

$$\begin{aligned} \omega_e &= 2.42 \text{ рад/с,} \\ R &= 3 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.21.**

9

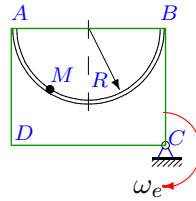


$$\sigma(t) = AM = \frac{3}{4}(t^2 + 3)t \text{ см.}$$

$$\begin{aligned} \varphi_e &= 0.15t^2, \\ AB &= 14 \text{ см,} \\ BC &= 16 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.22.**

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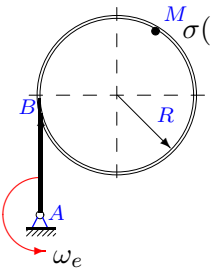


$$\sigma(t) = AM = \frac{\pi}{3}(t^2 + 51) \text{ см.}$$

$$\begin{aligned} \omega_e &= 0.05 \text{ рад/с,} \\ R &= 55 \text{ см,} \\ AD &= 57 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.23.**

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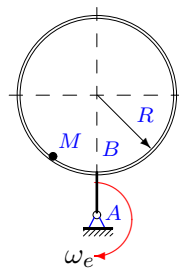


$$\sigma(t) = BM = \frac{2\pi}{3}(t^2 + 2)t \text{ см.}$$

$$\begin{aligned} \omega_e &= 0.91 \text{ рад/с,} \\ R &= 3 \text{ см,} \\ AB &= 8 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.24.**

9

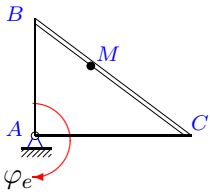


$$\sigma(t) = BM = \frac{3\pi}{4}(t^3 + 3) \text{ см.}$$

$$\begin{aligned} \omega_e &= 1.27 \text{ рад/с,} \\ R &= 11 \text{ см,} \\ AB &= 2 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.25.**

9

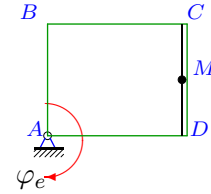


$$\sigma(t) = BM = \frac{2}{3}(t^2 + 4)t \text{ см.}$$

$$\begin{aligned} \varphi_e &= 0.15t^2, \\ AB &= 20 \text{ см,} \\ AC &= 35 \text{ см,} \\ t_1 &= 3 \text{ с.} \end{aligned}$$

**Задача 10.26.**

9

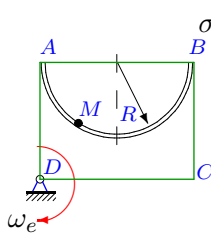


$$\sigma(t) = DM = \frac{5}{6}(t^2 + 52) \text{ см.}$$

$$\begin{aligned} \varphi_e &= 0.01t^2, \\ AB &= 61 \text{ см,} \\ BC &= 63 \text{ см,} \\ t_1 &= 3 \text{ с.} \end{aligned}$$

**Задача 10.27.**

9

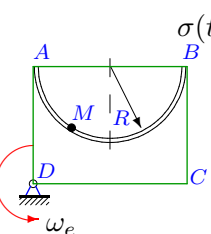


$$\sigma(t) = AM = \frac{\pi}{6}(t^2 + 4t) \text{ см.}$$

$$\begin{aligned} \omega_e &= 0.51 \text{ рад/с,} \\ R &= 12 \text{ см,} \\ AD &= 14 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.28.**

9



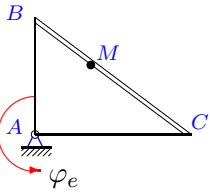
$$\sigma(t) = AM = \frac{3\pi}{4}(t^2 + 6t) \text{ см.}$$

$$\begin{aligned} \omega_e &= 0.6 \text{ рад/с,} \\ R &= 27 \text{ см,} \\ AD &= 29 \text{ см,} \\ t_1 &= 3 \text{ с.} \end{aligned}$$

**Задача 10.29.**

9

$$\sigma(t) = BM = \frac{3}{4}(t^3 + 4) \text{ см.}$$

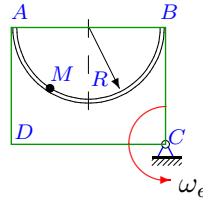


$$\begin{aligned} \varphi_e &= 0.16t^2, \\ AB &= 16 \text{ см,} \\ AC &= 28 \text{ см,} \\ t_1 &= 3 \text{ с.} \end{aligned}$$

**Задача 10.30.**

9

$$\sigma(t) = AM = \frac{\pi}{3}(t^3 + 3) \text{ см.}$$

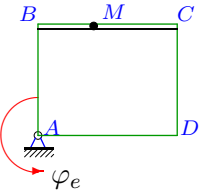


$$\begin{aligned} \omega_e &= 0.75 \text{ рад/с,} \\ R &= 11 \text{ см,} \\ AD &= 13 \text{ см,} \\ t_1 &= 2 \text{ с.} \end{aligned}$$

**Задача 10.31.**

9

$$\sigma(t) = BM = \frac{1}{3}(t^2 + 2)t \text{ см.}$$

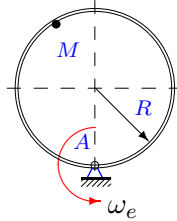


$$\begin{aligned} \varphi_e &= 0.37t^2, \\ AB &= 2 \text{ см,} \\ BC &= 3 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.32.**

9

$$\sigma(t) = AM = \frac{5\pi}{3}(t^2 + 2t) \text{ см.}$$

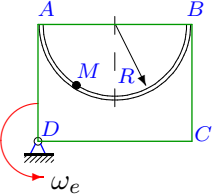


$$\begin{aligned} \omega_e &= 6.98 \text{ рад/с,} \\ R &= 3 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.33.**

9

$$\sigma(t) = AM = \frac{\pi}{4}(t^2 + 50) \text{ см.}$$

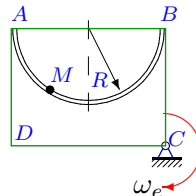


$$\begin{aligned} \omega_e &= 0.07 \text{ рад/с,} \\ R &= 51 \text{ см,} \\ AD &= 53 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Задача 10.34.**

9

$$\sigma(t) = AM = \frac{5\pi}{6}(t^3 + 2) \text{ см.}$$



$$\begin{aligned} \omega_e &= 2.23 \text{ рад/с,} \\ R &= 3 \text{ см,} \\ AD &= 5 \text{ см,} \\ t_1 &= 1 \text{ с.} \end{aligned}$$

**Сложное движение точки, плоская траектория**

№	$R_e$	$v_r$	$v_e$	$v$	$a_r$	$a_e$	$a_c$	$a$
	Радиус, см	Скорости, см/с			Ускорения, см/с <sup>2</sup>			
1	46.905	56.549	56.755	62.980	109.826	68.674	136.848	26.822
2	19.617	10.000	9.416	17.457	1.667	5.503	9.600	14.858
3	97.754	73.042	73.315	2.661	143.222	54.987	109.563	93.413
4	31.194	3.000	2.496	1.337	1.500	1.264	0.480	0.530
5	5.543	7.069	7.095	13.892	21.846	9.082	18.096	44.439
6	6.242	2.500	2.497	0.396	2.000	1.599	2.000	1.234
7	36.705	10.000	11.011	6.874	1.667	4.938	6.000	6.514
8	78.456	63.617	63.549	127.134	137.270	51.475	103.060	288.524
9	27.860	2.000	2.229	1.090	1.000	1.129	0.320	0.711
10	9.475	4.000	4.169	3.502	4.000	2.777	3.520	4.167
11	21.355	31.416	31.391	51.305	74.843	46.145	92.363	179.239
12	77.410	8.378	8.515	9.544	8.490	0.937	1.843	9.252
13	8.612	10.000	9.990	18.514	8.000	12.619	23.200	35.155
14	37.103	1.667	1.484	2.825	1.667	1.485	0.133	2.858
15	5.056	1.000	1.011	0.150	0.500	1.031	0.400	0.635
16	32.152	6.283	6.430	11.887	2.192	1.286	2.513	3.089
17	24.666	35.343	35.272	61.363	93.596	50.439	101.081	216.568
18	3.010	2.250	2.228	1.834	4.500	2.771	3.330	4.290
19	31.064	1.333	1.243	0.741	1.333	1.244	0.107	0.693
20	5.196	12.566	12.575	24.284	58.330	30.431	60.821	145.518
21	19.138	11.250	11.483	6.512	9.000	8.968	13.500	10.898
22	83.030	4.189	4.152	4.572	2.119	0.208	0.419	2.285
23	11.514	10.472	10.478	1.278	38.654	9.535	19.059	30.253
24	22.186	28.274	28.177	55.168	77.982	35.784	71.817	177.571
25	23.665	20.667	21.298	39.073	12.000	20.441	37.200	56.245
26	80.951	5.000	4.857	3.285	1.667	1.645	0.600	1.408
27	8.160	4.189	4.162	7.609	1.798	2.122	4.273	4.972
28	47.145	28.274	28.287	49.676	29.981	16.972	33.929	73.372
29	20.675	20.250	19.848	16.244	13.500	20.170	38.880	31.387
30	16.862	12.566	12.646	20.412	19.079	9.485	18.850	42.105
31	2.236	1.667	1.655	0.763	2.000	2.058	2.467	2.112
32	3.000	20.944	20.940	20.942	146.591	146.161	292.378	155.318
33	22.583	1.571	1.581	0.099	1.572	0.111	0.220	1.586
34	3.523	7.854	7.856	14.032	25.875	17.520	35.029	24.954

№	$a_r^n$	$a_r^T$	$a_e^n$	$a_e^T$	$a_x$	$a_y$
1	103.153	37.699	68.674	0.000	-18.585	-19.340
2	0.000	1.667	4.520	-3.139	-7.449	-12.855
3	136.798	42.412	54.987	0.000	26.719	-89.510
4	0.000	1.500	0.200	1.248	0.468	-0.249
5	16.655	14.137	9.082	0.000	38.044	-22.967
6	0.000	2.000	0.999	1.248	1.202	0.281
7	0.000	1.667	3.303	3.670	-5.640	-3.258
8	130.553	42.412	51.475	0.000	-169.921	-233.181
9	0.000	1.000	0.178	1.114	0.300	0.645
10	0.000	4.000	1.834	2.085	4.100	0.745
11	70.497	25.133	46.145	0.000	-105.043	145.232
12	1.376	8.378	0.937	0.000	-7.947	-4.736
13	0.000	8.000	11.588	-4.995	-13.520	-32.451
14	0.000	1.667	0.059	1.484	-1.507	-2.429
15	0.000	0.500	0.202	1.011	-0.350	-0.530
16	0.647	2.094	1.286	0.000	-0.339	-3.070
17	89.223	28.274	50.439	0.000	-163.444	142.083
18	0.000	4.500	1.648	2.228	1.788	3.900
19	0.000	1.333	0.050	1.243	0.321	-0.615
20	52.638	25.133	30.431	0.000	-100.907	-104.849
21	0.000	9.000	6.890	5.741	-10.890	0.420
22	0.319	2.094	0.208	0.000	1.970	-1.157
23	36.554	12.566	9.535	0.000	-1.591	-30.211
24	72.676	28.274	35.784	0.000	134.710	-115.692
25	0.000	12.000	19.168	-7.099	-24.193	-50.776
26	0.000	1.667	0.291	-1.619	1.390	0.224
27	1.462	1.047	2.122	0.000	-2.328	-4.393
28	29.609	4.712	16.972	0.000	-58.189	44.693
29	0.000	13.500	19.054	6.616	10.978	29.404
30	14.356	12.566	9.485	0.000	36.767	20.520
31	0.000	2.000	1.224	1.655	-0.028	2.111
32	146.216	10.472	146.161	0.000	-5.236	-155.230
33	0.048	1.571	0.111	0.000	1.227	-1.004
34	20.562	15.708	17.520	0.000	22.382	-11.035