P54. 2.10. 解：(1) 由牛顿第二定律：

$$F_{合} = -kv = ma = m\frac{dv}{dt}$$

分离变量：$-\frac{k}{m}dt = \frac{dv}{v}$

$$\int_{v_0}^{v}\frac{dv}{v} = \int_0^t -\frac{k}{m}dt$$

$$\ln\frac{v}{v_0} = -\frac{k}{m}t$$

$$v = v_0 e^{-\frac{k}{m}t}$$

(2)

$$x = \int_0^t v\,dt = \int_0^t v_0 e^{-\frac{k}{m}t}dt = \frac{mv_0}{k}\left(1-e^{-\frac{k}{m}t}\right)$$

(3) 当 $t\to\infty$ $x = \frac{mv_0}{k}$

(4) 当 $t=\frac{m}{k}$，$v = v_0 e^{-\frac{k}{m}\cdot\frac{m}{k}} = v_0 e^{-1}$

$\therefore \frac{v}{v_0} = \frac{1}{e}$

P77. 3.12 解：设左侧绳子拉力为 T_1，右侧绳子拉力为 T_2，

由题意得：

$$\begin{cases} m_2 g - T_2 = m_2 a_2 \\ T_1 - m_1 g = m_1 a_1 \\ T_2 R - T_1 r = \left(\frac12 mr^2 + \frac12 MR^2\right)\alpha \\ a_1 = \alpha r \\ a_2 = \alpha R \end{cases}$$

代入数据：

$$\begin{cases} 2\times 9.8 - T_2 = 2a_2 \\ T_1 - 2\times 9.8 = 2a_1 \\ T_2\times 0.2 - T_1\times 0.1 = \left(\frac12\times 4\times 0.1^2 + \frac12\times 10\times 0.2^2\right)\alpha \\ a_1 = 0.1\times\alpha \\ a_2 = 0.2\times\alpha \end{cases}$$

解得：

$$\begin{cases} \alpha = 6.125\ \text{rad/s}^2 \\ T_1 = 20.825\ \text{N} \\ T_2 = 17.15\ \text{N} \end{cases}$$

3.14 解：(1) $mg\frac{l}{2} = J\alpha = \frac13 ml^2\alpha$

$$\alpha = \frac{3g}{2l}$$

(2) 由机械能守恒可得：

$$mg\frac{l}{2}\sin\theta = \frac12 J\omega^2 = \frac12\cdot\frac13 ml^2\omega^2$$

$$\omega = \sqrt{\frac{3g}{l}\sin\theta}$$

3.15 解：(1) 碰撞瞬间，角动量守恒

可得：$mv_0 l = mvl + \frac13 Ml^2\omega$

由于是弹性碰撞，动能守恒：

$$\frac12 mv_0^2 = \frac12 mv^2 + \frac12\cdot\frac13 Ml^2\omega^2$$

杆子上摆过程，机械能守恒：

$$\frac12\cdot\frac13 Ml^2\omega^2 = Mg\frac{l}{2}(1-\cos 30^\circ)$$

解得：$v_0 = \frac{\sqrt{6(2-\sqrt3)gl}}{12}\cdot\frac{3m+M}{m}$

(2) 小球受到的冲量为其动量的改变：

$$\Delta p = mv - mv_0 = -\frac{\sqrt{6(2-\sqrt3)gl}}{6}M$$

3.16 解：(1) 飞出去一瞬间，碎片的角速度为 ω.

$\therefore v = \omega R$.

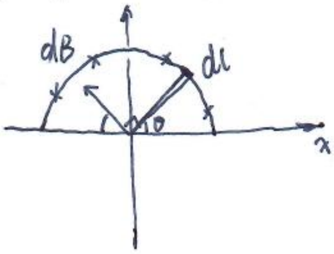
$\therefore h = \frac{v^2}{2g} = \frac{\omega^2R^2}{2g}$.

(2) 由于碎片飞出的瞬间，角动量守恒，故飞轮的角速度不变，仍为 ω.

$\therefore$ 角动量大小，$L = J\omega = \left(\frac12 MR^2 - mR^2\right)\omega$

转动动能 $E_k = \frac12 J\omega^2 = \frac12\left(\frac12 MR^2 - mR^2\right)\omega^2$

10.11 解：利用无限长通电直导线之结论 $B=\frac{\mu_0 I}{2\pi r}$



单位弧度之电流 $j=\frac{I}{\pi R}$.

$dI=\frac{I}{\pi R}\cdot dl=\frac{I}{\pi}d\theta$

$dB=\frac{\mu_0}{2\pi R}\cdot dI$

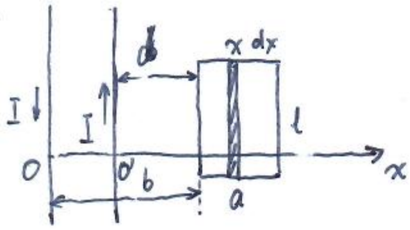
$dB_x=dB\cdot\cos(\frac{\pi}{2}-\theta)=dB\cdot\sin\theta$

$B_x=\int dB_x=\int_0^{\pi}\frac{\mu_0}{2\pi R}\cdot\frac{I}{\pi}d\theta\cdot\sin\theta$

$=\frac{\mu_0 I}{\pi^2 R}=\frac{4\pi\times10^{-7}\times5}{\pi^2\times0.01}=6.37\times10^{-5}T$

11.6 解：

(1)



解：如图建立坐标系：~~B=~~

对于左边电流 I，$B=\frac{\mu_0 I}{2\pi x}$

$\phi=\int_b^{b+a}\frac{\mu_0 I}{2\pi x}\cdot l\cdot dx=\frac{\mu_0 I l}{2\pi}\ln\frac{b+a}{b}$

对于右边电流 I

$\phi'=\int_d^{d+a}\frac{\mu_0 I}{2\pi x}\cdot l\cdot dx=\frac{\mu_0 I l}{2\pi}\ln\frac{d+a}{d}$

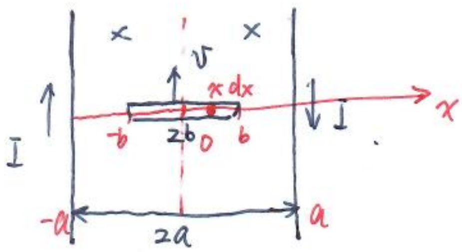
以电流方向相反.

$\phi_{总}=\phi'-\phi=\frac{\mu_0 I l}{2\pi}(\ln\frac{d+a}{d}-\ln\frac{b+a}{b})$

$=\frac{\mu_0 I l}{2\pi}\ln\frac{(d+a)b}{d(b+a)}$

(2) $\varepsilon=-\frac{d\phi}{dt}=-\left[\frac{\mu_0 l}{2\pi}\ln\frac{(d+a)b}{d(b+a)}\right]\frac{dI}{dt}$.

11.12 解：



如图建立坐标系：

$B=\frac{\mu_0 I}{2\pi(a+x)}+\frac{\mu_0 I}{2\pi(a-x)}$

$d\varepsilon=B\cdot v\cdot dx$

~~$\varepsilon=\int_{-b}^{b}[\frac{\mu_0 I}{2\pi(a+x)}+\frac{\mu_0 I}{2\pi x}]\cdot v\cdot dx$~~

$\varepsilon=\int_{-b}^{b}[\frac{\mu_0 I}{2\pi(a+x)}+\frac{\mu_0 I}{2\pi(a-x)}]\cdot v\,dx$

$=\frac{\mu_0 I v}{\pi}\ln\frac{a+b}{a-b}$

左端为正极.

右端为负极.