1. Rubber fiber (12 pts)

1) Volume conservation: $Sl = S_0 l_0$, hence $S = S_0 l_0 / l$.

2) At the limit of small deformations, $F(l) = a + \frac{b}{l} \approx a - bx/l_0^2 = k_0 x$, hence $E_0 S_0 / l_0 = -b/l_0^2$, hence $b = -E_0 S_0 l_0$ (1 pt). Besides, at $l = l_0$, $F = 0$ (0.5 pts), hence $a + \frac{b}{l_0} = 0$ and $a = E_0 S_0$ (1 pt).

3) $\Delta F \approx \frac{dF}{dl}\, dl = E_0 S_0 \frac{l_0\, \delta l}{l^2}$.

4) Newton II law: $E_0 S_0 (1 - \frac{l_0}{l}) = \frac{2K}{l}$, hence $l = l_0 + \frac{2K}{E_0 S_O}$.

5) Conservation of angular momentum: $l v_t = L V_t$, hence $v_t = V_t \frac{L}{L+r}$ (1.5 pts). Conservation of energy: $\frac{m}{2}(v_t^2 + v_r^2) + E_0 S_0 (r - l_0 \ln \frac{r+L}{L}) = \frac{m}{2}(V_t^2 + V_r^2)$ (2 pts).

6) Substituting v_t from the angular momentum conservation law into the energy equation we obtain $\frac{m}{2}[V_t^2 (\frac{L}{L+r})^2 + v_r^2] + E_0 S_0 (r - l_0 \ln \frac{r+L}{L}) = \frac{m}{2}(V_t^2 + V_r^2)$ (0.4 pts). Further we make use of condition $|r| \ll L$ and substitute $(\frac{L}{L+r})^2 \approx 1 - 2\frac{r}{L} + 3(\frac{r}{L})^2$ (0.4 pts), $\ln \frac{r+L}{L} \approx \frac{r}{L} - \frac{1}{2}(\frac{r}{L})^2$ (0.4 pts). Linear in r terms cancel out due to the condition $E_0 S_0 (1 - \frac{l_0}{L}) = m V_t^2 / L$ (0.4 pts). So, we arrive at $\frac{m}{2}[3V_t^2 (\frac{r}{L})^2 + v_r^2] + \frac{1}{2} E_0 S_0 l_0 (\frac{r}{L})^2 = \frac{m}{2} V_r^2$ (0.4 pts). This is the energy conservation law for a pendulum consisting of a spring with effective stiffness $k_{\text{eff}} = (3mV_t^2 + E_0 S_0 l_0) L^{-2}$ and of a body with effective mass $m_{\text{eff}} = m$ (0.5 pts). So, $T = 2\pi L / \sqrt{3V_t^2 + E_0 S_0 l_0 m^{-1}} \approx 2\pi L / \sqrt{3} V_t$ (0.3+0.2 pts).