# Physics 4210/5210 Theoretical Mechanics Fall 2025 - Exam 2

[1] An undamped oscillator has period $\tau_0 = 1$ second. When weak damping is added, it is found that the amplitude of oscillation drops by 50% in one period $\tau_1$.
(a) How big is $\beta/\omega_0$? [**2 point**]
(b) What is $\tau_1$? [**2 points**]

[2] Figure 1 shows a simple pendulum (mass *m,* length $\lambda$) whose point of support *P* is attached to the edge of a wheel (center O*,* radius R*)* that is forced to rotate at a fixed angular velocity $\omega$. At t = 0, point *P* is level with O on the right.
(a) Write down **r**(t). [**1 points**]
(b) Write down v(t). [**1 points**]
(c) Write down the Lagrangian? [**1 points**]
(d) Find the equation of motion for the angle $\phi$. [**3 points**]

[3] A simple pendulum (mass *M* and length *L)* is suspended from a cart (mass m) that can oscillate on the end of a constant spring *k,* as shown in Figure 2.
(a) Write the Lagrangian in terms of the two generalized coordinates *x* and $\phi$, where x is the extension of the spring from its equilibrium length. [**2 points**]
(b) Find the two Lagrange equations. [**2 points**]
(c) Simplify the equations to the case that both x and $\phi$ are small. [**2 points**]

[4] A particle of mass *m* moves with angular momentum about a fixed force center with $F(r) = k/r^3$ where *k* can be positive or negative.
**(a)** Sketch the effective potential energy $U_{eff}$ for various values of *k* and describe the various possible kinds of orbit. [**2 points**]
**(b)** Write down and solve the transformed radial equation and use your solutions to confirm your predictions in part (a). [**5 points**]

Fig. 1

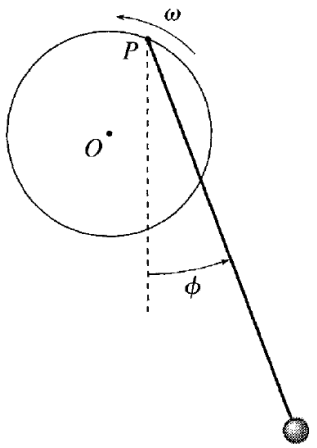

Fig. 2