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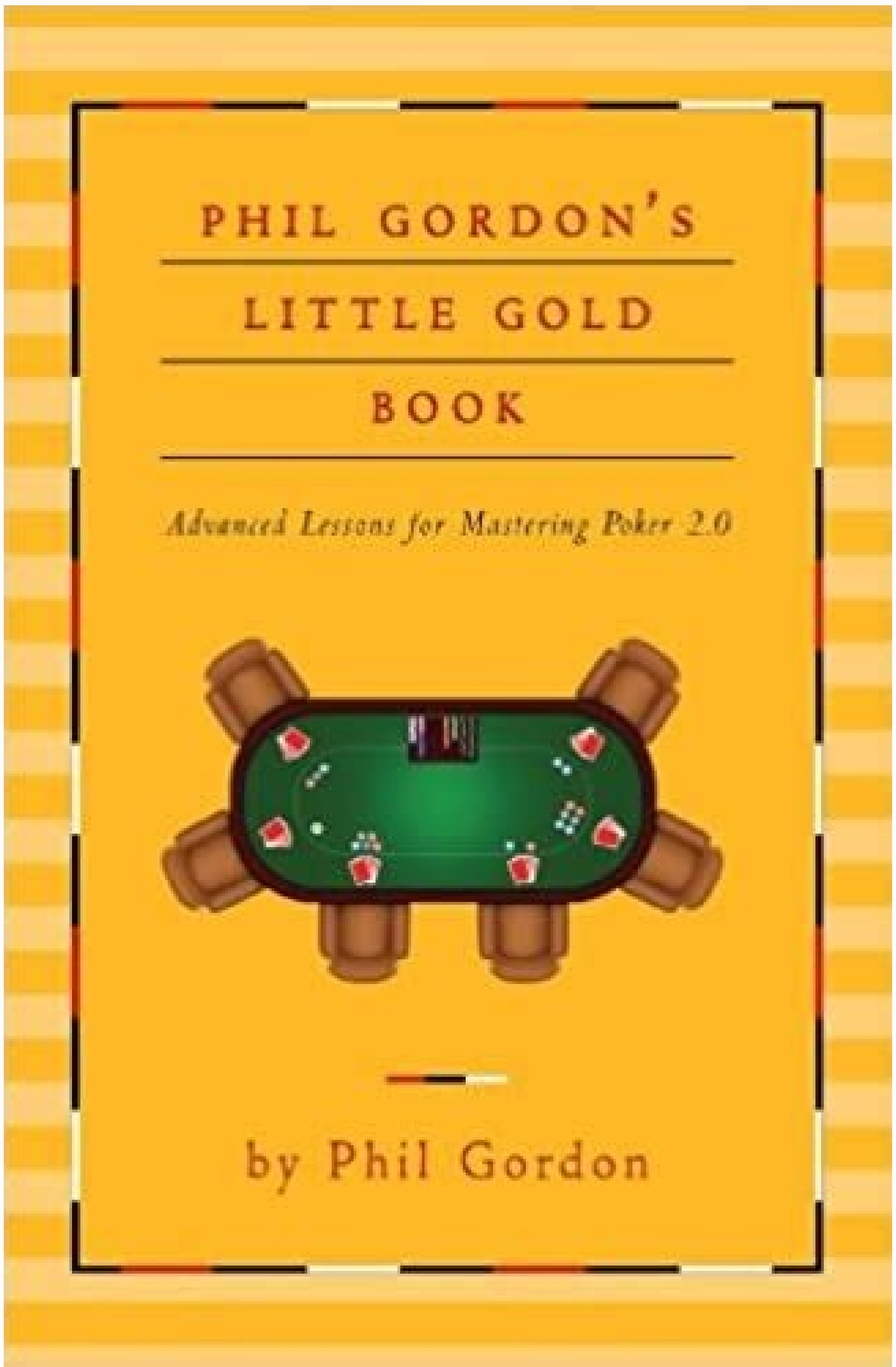
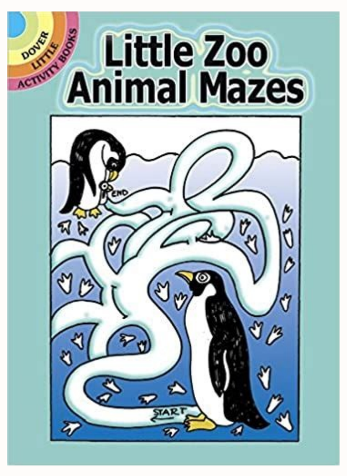
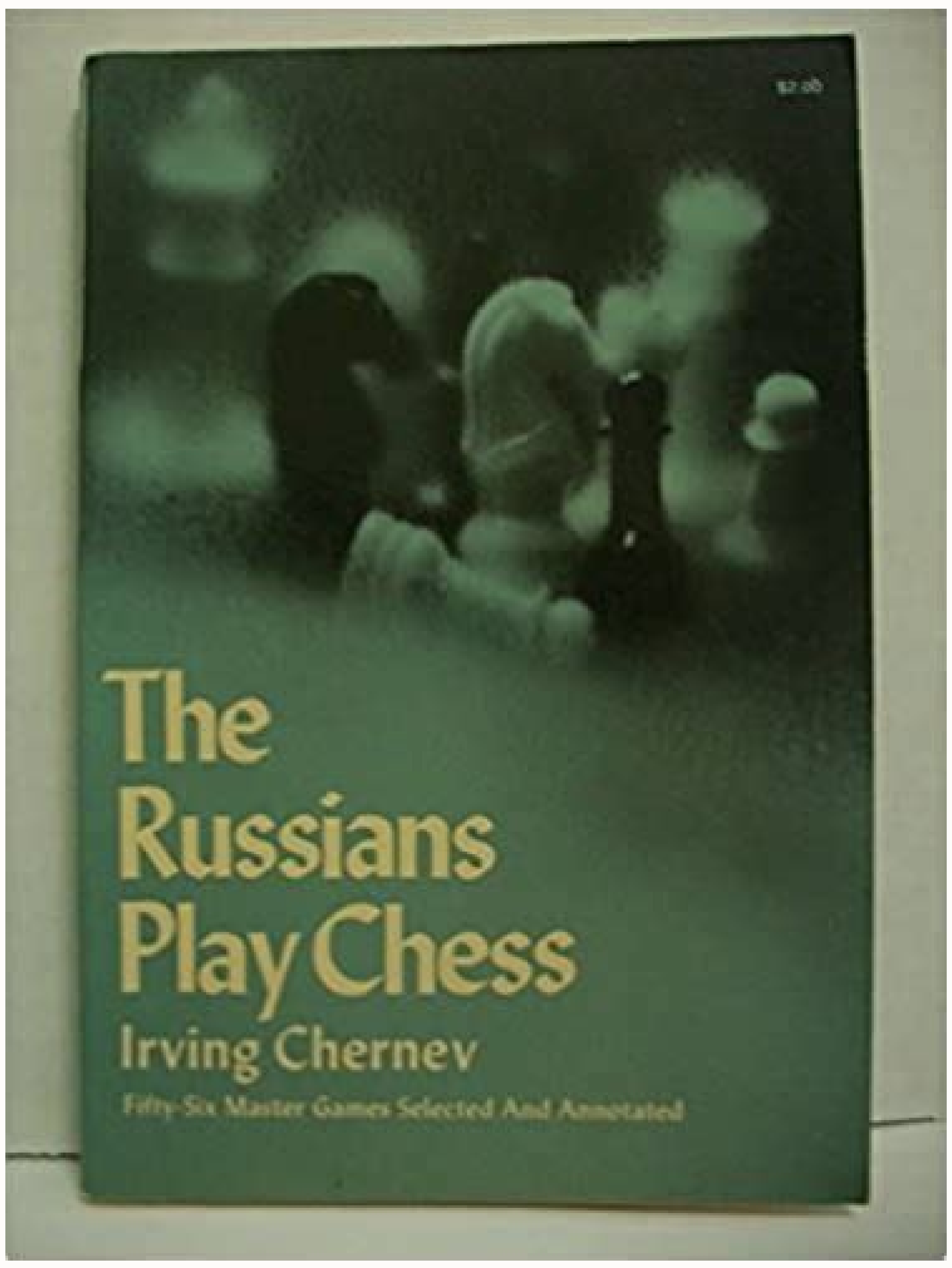
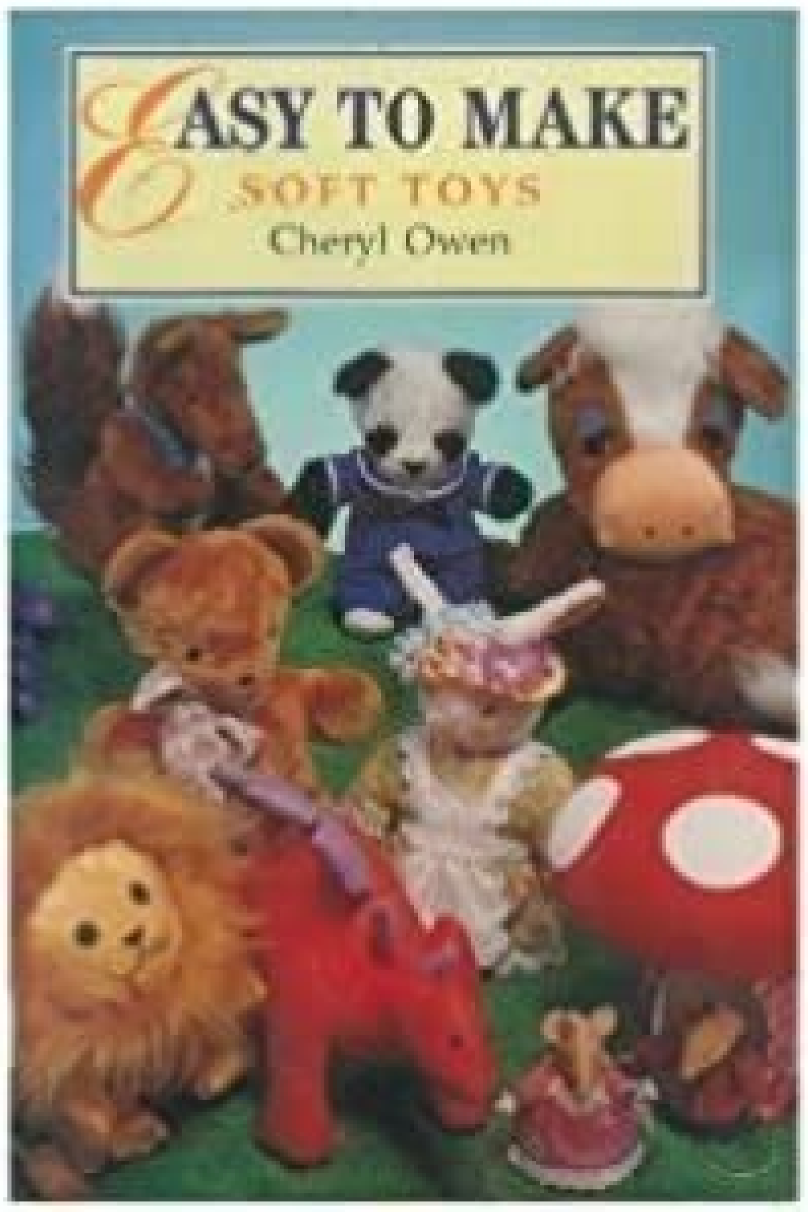
Classical mechanics taylor chapter 7 solutions answers pdf answers









The method of Lagrange multipliers works perfectly well with non-Cartesian coordinates. What is the frequency of these oscillations if their amplitude is small? Check that the acceleration of the block is given correctly in the limit $M \rightarrow 0 .$ [You need to find the components of this acceleration relative to the table.] A smooth wire is bent into the shape of a helix, with cylindrical polar coordinates $\rho=R$ and $z=\lambda \phi,$ where R and λ are constants and the z axis is vertically up (and gravity vertically down). Comparing these with the two components of Newton's second law, show that the Lagrange multiplier is (minus) the tension in the rod. (b) Write down the Lagrangian $\mathcal{L}\left(\mathbf{r}_{1}, \mathbf{r}_{2}, \dot{\mathbf{r}}_{1}, \dot{\mathbf{r}}_{2}\right)=T-U$ and show that the six Lagrange equations are the same as the six Newtonian equations of part (a). Hence show that $$\sum_{\alpha=1}^{N} \frac{\partial \mathcal{L}}{\partial \phi_{\alpha}}=0.$$ (b) Use Lagrange's equations to show that this implies that the total angular momentum L_{z} about the symmetry axis is constant. Meanwhile, we take for granted that the nonconstraint forces are derivable from a potential energy $U\left(\mathbf{r}_{1}, \mathbf{r}_{2}, t\right) ;$ that is, $\mathbf{F}_{1}=-abla_{1} U$ and likewise for particle $2 .$ Write down the difference δS between the action integral for the right path given by $\mathbf{r}_{1}(t)$ and $\mathbf{r}_{2}(t)$ and any nearby wrong path given by $\mathbf{r}_{1}(t)+\epsilon_{1}(t)$ and $\mathbf{r}_{2}(t)+\epsilon_{2}(t) .$ Paralleling the steps of Section $7.4,$ you can show that δS is given by an integral analogous to $(7.49),$ and this is zero by the defining property of constraint forces.] Figure 7.12 shows a crude model of a yoyo. Notice that you need the result of part (a).] This identity is useful in many areas of physics; we needed it to prove the expression (7.96) for the generalized momentum p_{i}. A pendulum is made from a massless spring (force constant k and unstretched length l_{o}) that is suspended at one end from a fixed pivot O and has a mass m attached to its other end. (b) Write down the three Lagrange equations and explain their significance in terms of radial acceleration, angular momentum, and so forth. These coordinates are constrained to satisfy the constraint equation $f(x, y)=$ $\sqrt{x^{2}+y^{2}}=l .$ (a) Write down the two modified Lagrange equations (7.118) and (7.119). Set up the Lagrangian for the motion of the small cart and show that the Lagrange equation has the form $$\ddot{x}+\omega_{0}^{2} x=B \cos \omega t$$ where ω_{o} is the natural frequency $\omega_{\mathrm{o}}=\sqrt{k / m}$ and B is a constant. (They're still pretty ugly, and note, in particular, that they are still coupled; that is, each equation involves both variables. [Hint: Remember that the change in the scalar $f \text { as a result of an infinitesimal displacement } d \mathbf{r} \text { is } d f=abla f \cdot d \mathbf{r}.]$ Consider two particles moving unconstrained in three dimensions, with potential energy $U\left(\mathbf{r}_{1}, \mathbf{r}_{2}\right) .$ (a) Write down the six equations of motion obtained by applying Newton's second law to each particle. At $t=0,$ the point P is level with O on the right. Verify Equation (7.122) and the corresponding equation in $y .$ (b) The constraint equation can be written in many different ways. What is the frequency of small oscillations about this equilibrium position? [This is the potential energy of an ion in an "ion trap," which can be used to study the properties of individual atomic ions.] Consider a mass m moving in a frictionless plane that slopes at an angle α with the horizontal. Using the usual angle ϕ as generalized coordinate, write down the Lagrangian for a simple pendulum of length l suspended from the ceiling of an elevator that is accelerating upward with constant acceleration a. Find the equation of motion and show that, provided $m0$ may depend on q but not on $\dot{q}$. This is the form assumed in Section 5.5, Equation (5.57), for driven oscillations (except that we are here ignoring damping). In Chapter 4 (at the end of Section 4.7) I claimed that, for a system with one degree of freedom, positions of stable equilibrium "normally" correspond to minima of the potential energy $U(q) .$ Using Lagrangian mechanics, you can now prove this claim. Lagrange's equations in the form discussed in this chapter hold only if the forces (at least the nonconstraint forces) are derivable from a potential energy. One might expect that the rotation of the wheel would have little effect on the pendulum, provided the wheel is small and rotates slowly. [Hint: Let l denote the equilibrium length of the spring with the mass hanging from it and write $r=l+\epsilon .$ "Small oscillations" involve only small values of ϵ and $\phi,$ so you can use the small-angle approximations and drop from your equations all terms that involve powers of ϵ or ϕ (or their derivatives) higher than the first power (also products of ϵ and ϕ or their derivatives). Consider a particle of mass m and charge q moving in a uniform constant magnetic field $\mathbf{B}$ in the z direction. Write $r(t)=r_{0}+\epsilon(t)$ and rewrite the r equation in terms of $\epsilon(t)$ dropping all powers of $\epsilon(t)$ higher than linear. (c) Express $\dot{\phi}$ in terms of ℓ and eliminate $\dot{\phi}$ from the r equation. (b) Write the Lagrangian (7.103) in cylindrical polar coordinates and find the three corresponding Lagrange equations. (b) Find the two Lagrange equations of the system and interpret them in terms of Newton's second law, as given in Equation (1.48). (d) If you did Problem 7.30 , show that the pendulum of that problem does not satisfy the conditions of this problem and that the result proved here is false for that system. Find the Lagrangian for this system using ϕ as your generalized coordinate. (A free-body diagram will help.) (b) Verify that the equilibrium point at the top $(\theta=\pi)$ is unstable. The distance of the small cart from its equilibrium is denoted x and that of the large one from a fixed point on the ground is $X,$ as shown in Figure $7.13 .$ The large cart is now forced to oscillate such that $X=A \cos \omega t,$ with both A and ω fixed. Thus the system described here would be one way to realize the motion discussed there. (a) Write down the Lagrangian for the pendulum, using as generalized coordinates the usual angle ϕ and the length r of the spring. (a) Write down the Lagrangian $\mathcal{L}$ in terms of the spherical polar coordinates r and ϕ. (a) Verify this expectation by solving the equation of motion numerically, with the following numbers: Take g and l to be 1 . Define the Lagrangian as $\mathcal{L}=T-U$ and show that the appropriate modification is $$\frac{\partial \mathcal{L}}{\partial x}+F_{\mathrm{fric}}=\frac{d}{d t} \frac{\partial \mathcal{L}}{\partial \dot{x}}.$$ In Section 7.4 [Equations (7.41) through (7.51)], I proved Lagrange's equations for a single particle constrained to move on a two-dimensional surface. (See Figure 4.28.) Initially I am holding the wheel with M vertically below the axle. Remember, however, that ℓ_{ϕ} is the component of ℓ in a variable direction.) (c) Suppose that initially the motion is in the equatorial plane (that is, $\theta_{0}=\pi / 2$ and $\dot{\theta}_{0}=0$). Find the Lagrange equation and hence the bead's vertical acceleration $\ddot{z}$. (c) Suppose that the particle is given a small radial kick, so that $r(t)=r_{\mathrm{o}}+\epsilon(t),$ where $\epsilon(t)$ is small. Use the following numbers: $g=R=1$ and $\omega^{2}=2,$ and initial conditions $\dot{\theta}(0)=0$ and $\theta(0)=\theta_{0}+\epsilon_{0},$ where $\epsilon_{0}=1^{\circ} .$ Repeat with $\epsilon_{\mathrm{o}}=10^{\circ} .$ Comment on your results. You can easily solve the homogeneous equation; for a particular solution try $x=A \sin \omega t$ and solve for A.] Consider the well-known problem of a cart of mass m moving along the x axis attached to a spring (force constant k), whose other end is held fixed (Figure 5.2). A small cart (mass m) is mounted on rails inside a large cart. Use the r equation to decide whether the circular path is stable. (c) Because the equation of motion cannot be solved in terms of elementary functions, you are going to solve it numerically. (b) Assuming $m

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