Homework 1 (Due to September 14, 2017).
Chapter 1. Newton's Laws of Motion.

Problem 1.9. (J. Taylor "Classical Mechanics") **(10 points)**

1.9 ⋆ In elementary trigonometry, you probably learned the law of cosines for a triangle of sides a, b, and c, that $c^2 = a^2 + b^2 - 2ab\cos\theta$, where θ is the angle between the sides a and b. Show that the law of cosines is an immediate consequence of the identity $(\mathbf{a} + \mathbf{b})^2 = a^2 + b^2 + 2\mathbf{a}\cdot\mathbf{b}$.

Problem 1.11. (J. Taylor "Classical Mechanics") **(10 points)**

Describe the particle's orbit (find the equation of the orbit, direction of motion, period of rotation, absolute value of velocity and acceleration).

1.11 ⋆ The position of a moving particle is given as a function of time t to be

$$\mathbf{r}(t) = \hat{\mathbf{x}}b\cos(\omega t) + \hat{\mathbf{y}}c\sin(\omega t),$$

where b, c, and ω are constants. Describe the particle's orbit.

Problem 1.39. (J. Taylor "Classical Mechanics") **(10 points)**

1.39 ⋆⋆ A ball is thrown with initial speed v_0 up an inclined plane. The plane is inclined at an angle ϕ above the horizontal, and the ball's initial velocity is at an angle θ above the plane. Choose axes with x measured up the slope, y normal to the slope, and z across it. Write down Newton's second law using these axes and find the ball's position as a function of time. Show that the ball lands a distance $R = 2v_0^2\sin\theta\cos(\theta+\phi)/(g\cos^2\phi)$ from its launch point. Show that for given v_0 and ϕ, the maximum possible range up the inclined plane is $R_{\max} = v_0^2/[g(1+\sin\phi)]$.

Problem 1.49. (J. Taylor "Classical Mechanics"). **(10 points)**

1.49 ⋆⋆ Imagine two concentric cylinders, centered on the vertical z axis, with radii $R \pm \epsilon$, where ϵ is very small. A small frictionless puck of thickness 2ϵ is inserted between the two cylinders, so that it can be considered a point mass that can move freely at a fixed distance from the vertical axis. If we use cylindrical polar coordinates (ρ, ϕ, z) for its position (Problem 1.47), then ρ is fixed at $\rho = R$, while ϕ and z can vary at will. Write down and solve Newton's second law for the general motion of the puck, including the effects of gravity. Describe the puck's motion.

Present A. **(10 points)**

Three freight cars of mass M are pulled with force F by a locomotive. Friction is negligible. Find the forces on each car.