BRAC University

Department of Mathematics & Natural Sciences

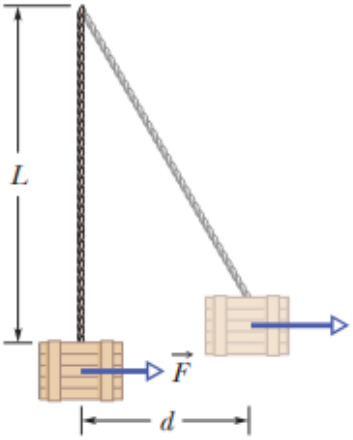
Principles of Physics-I (PHY 111)

Assignment II, Submission Date: April 30, 2025

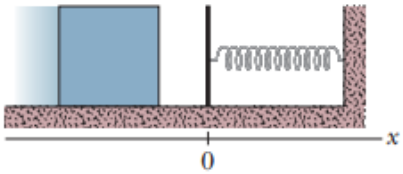
Section 1 | Spring, 2025 | Full marks: 50

1. Find the total work done in moving a particle in a force field given by, $\vec{F} = 3xy\hat{x} - 5z\hat{y} + 10x\hat{z}$ along the curve $x = t^2 + 1$, $y = 2t^2$, $z = t^3$ from $t = 1$ to $t = 2$. Where all quantities are in S.I. units. [3]

2. If the magnitude of the force of attraction between a particle of mass m_1 and one of mass m_2 is given by, $F = k\frac{m_1 m_2}{x^2}$, where k is a constant and x is the distance between the particles, find (a) the potential energy function, $U(x)$ (Assume that $U(x) \to 0$ as $x \to \infty$ and that x is positive) and (b) the work required to increase the separation of the masses from $x = x_1$ to $x = x_1 + d$. [2 + 2]

3. 

A 230 kg crate hangs from the end of a rope of length $L = 12.0$ m. You push horizontally on the crate with a varying force $\vec{F}$ to move it distance $d = 4.00$ m to the side (*fig*). Consider that the crate is motionless before and after its displacement.
(a) Why the force $\vec{F}$ is varying? [1]
(b) What is the magnitude of $\vec{F}$ when the crate is in this final position? [3]
(c) What is the total work done on the crate? [1]
(d) What are the work done by (i) the gravitational force, (ii) the pull force (from the rope) and (iii) your force $\vec{F}$ on the crate? [3]
(e) Why is the work done by your force not equal to the product of the horizontal displacement and the answer to (b)? [2]

4. 

In Figure, a block of mass $m = 2.5\ kg$ slides head on into a spring of spring constant $k = 320\ N/m$. When the block stops, it has compressed the spring by 7.5 cm. The coefficient of kinetic friction between block and floor is 0.25. While the block is in

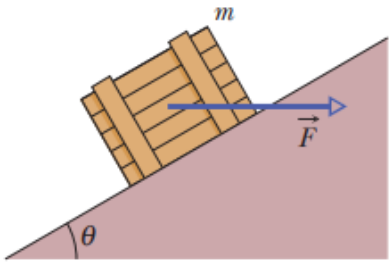
contact with the spring and being brought to rest, what are (a) the work done by the spring force and (b) the increase in thermal energy of the block–floor system? (c) What is the block's speed just as it reaches the spring? [2+2+2]

5. The so-called Yukawa potential

$$U(r) = -\frac{r_0}{r} U_0 e^{-r/r_0}$$

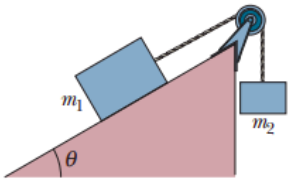
gives a fairly accurate description of the interaction between nucleons (that is, neutrons and protons, the constituents of the nucleus). The constant r_0 is about 1.5×10^{-15} meter and the constant U_0 is about 50 Mev.

(a) Find the corresponding expression for the force of attraction. [2]
(b) To show the short range of this force, compute the ratio of the force at $r = 2r_0$, and $10r_0$ to the force at $r = r_0$. [2]

6. 

In *Figure* shows a crate of mass $m = 100\ kg$ is pushed at constant speed up a ramp ($\theta = 30°$) by a horizontal force $\vec{F}$. Between the ramp and the crate, the coefficient of static friction is 0.25, and the coefficient of kinetic friction is 0.15.

(a) Draw the free-body diagram of above case. [2]
(b) Find the magnitude of the force, $\vec{F}$. [3]
(c) What is magnitude of the force on the crate from the ramp? [1]
(d) During moving at constant speed, if the crate travels distance $d = 100\ cm$. Find the net work on the crate. [1]

7. 

In *Figure*, a block of mass $m_1 = 3.50\ kg$ on a frictionless plane inclined at angle $\theta = 30.0°$ is connected by a cord over a massless, frictionless pulley to a second block of mass $m_2 = 2.50\ kg$.

(a) Find the normal force acting on the block m_1. [1]
(b) What is the magnitude of the acceleration of each block? [3]
(c) Find the tension in the cord. [2]
(d) During the acceleration, if the two blocks travel the same distance $d = 20\ cm$, what is the net work done on each block? [3]

(e) Using the Work-Kinetic Energy theorem, find the speed of each block after traveling the distance $d = 20\ cm$. Consider that initially, each block was at rest. [2]

8. In a hydrogen atom, an electron is bound to a nucleus in circular orbits by electric potential energy given by $U(r) = -k\frac{e^2}{r}$, where k is a constant that depends on the medium, e represents the charge of the electron , and r is the radius of the circular orbits.
(a) Since the electric force is conservative, find the force acting on the circulating electron. [2]
(b) The force found in part (a) is always directed toward the nucleus, it is the centripetal force that causes the electron to experience centripetal acceleration, a_c. When an electron moves around the nucleus in a circular orbit with a uniform velocity magnitude of v, find the expression for the electron's velocity v in terms of r. Consider the mass of the electron as m_e. [2]
(c) Calculate the work done by the electric force on the electron in the hydrogen atom. According to the work-energy theorem, justify your answer. [1]