Kuwait University   Physics Department

Physics 101

Spring Semester

Second Midterm Exam

Saturday, May 4, 2024

9:00 AM – 10:30 AM

Student's Name: ……………………………… Serial Number: ……………

Student's Number: ………………………………….Section: ……………………

Choose your Instructor's Name:

Instructors: Drs. Al Dosari, Al Jassar, Al kurtas, Al Qattan, Al Refai, Al Smadi, Askar, Demir, Salameh

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	SP5	LP1	LP2	Q1	Q2	Q3	Q4	Total
Pts	2	2	2	2	2	3	3	1	1	1	1	20

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 20 points as arranged in the above table.
3. **Give your final answer in the correct units.**
4. Assume g = 10 m/s^2.
5. Mobiles are **strictly prohibited** during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Model Answer

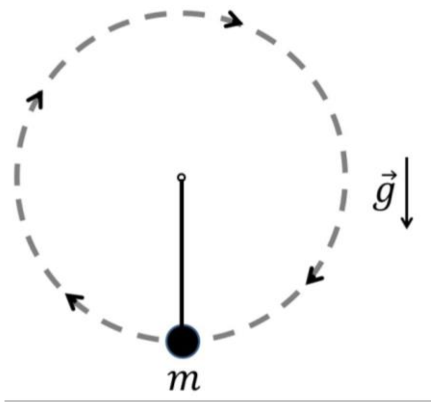
Part I: Short Problems (2 points each)

SP1. A constant force $\vec{F} = (30\hat{\imath} - 35\hat{\jmath})\ N$ acts on a particle that undergoes a displacement of $\vec{s} = (-3\hat{\imath} + 4\hat{\jmath})\ m$ in an interval of 4 seconds. **Find the average power delivered by $\vec{F}$ during this interval.**

$$w = \vec{F} \cdot \vec{S} = (30)(-3) + (-35)(4) = -230\ J$$

$$P_{av} = \frac{w}{t} = \frac{-230}{4} = -57.5\ W$$

SP2. A ball of mass $m = 3\ kg$ attached to a light string of length $L = 2\ m$ **rotates in a vertical circle,** as shown. If the speed of the ball **at the bottom** of the circle is $6\ m/s$, **find the tension in the rope at this point.**



$$T - mg = m\frac{v^2}{R}$$

$$T = m\left(g + \frac{v^2}{R}\right) = 3\left(10 + \frac{6^2}{2}\right) = 84\ N$$

SP3. A 3 kg block rests on a frictionless horizontal surface. **A variable** force $F(x) = 6x^2 + 4$, where $F(x)$ is measured in N and x is measured in m, starts acting on the block. If the block **starts from rest at the origin**, **use the work-energy theorem to find its speed at $x = 2\ m$.**

$$w_{F_x} = \int_{x_i}^{x_f} F_x\, dx = \int_0^2 (6x^2 + 4)\, dx = [2x^3 + 4x]_0^2 = 24\ J$$

$$\sum w = w_{F_x} = \Delta K = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = \frac{1}{2}mv_f^2$$

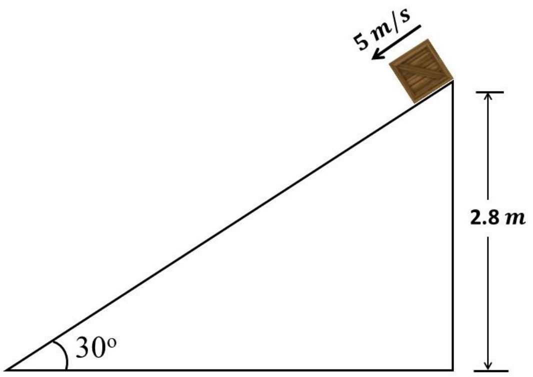
$$\Rightarrow v_f = \sqrt{\frac{2w_{F_x}}{m}} = \sqrt{\frac{2(24)}{3}} = 4\ m/s$$

SP4. A block of mass $m = 1.2\ kg$ is projected from the top of <u>**a frictionless**</u> **incline** with speed $v = 5\ m/s$, as shown. **find the speed of the block at the bottom of the incline.**

$$E_f = E_i$$

$$\frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2 + mgh$$

$$v_f = \sqrt{v_i^2 + 2gh} = 9\ m/s$$



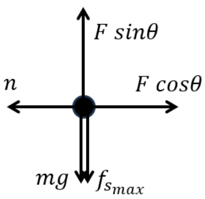
SP5. A block of mass $m = 4.4\ kg$ is held against a wall by a force $\vec{F}$ that makes an angle $\theta = 53.1°$ with horizontal, as shown. The coefficient of static friction between the block and the wall is $\mu_S = 0.5$. Find the <u>**maximum**</u> **value of the magnitude of F** <u>**to prevent the block from sliding up**</u>**.**

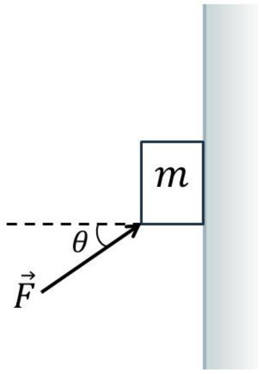
$$n = F\ cos\theta$$

$$F\ sin\theta - mg - f_{s_{max}} = 0$$

$$F\ sin\theta - mg - \mu_s F\ cos\theta = 0$$

$$F = \frac{mg}{sin\theta - \mu_s\ cos\theta} = 88.1\ N$$

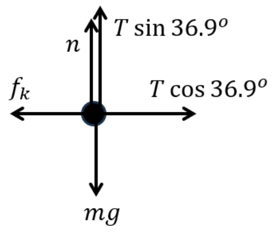


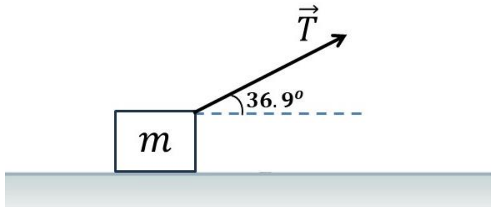


Part III: Long Problems (3 points each)

LP1. A block of mass $m = 12\ kg$ on a **rough horizontal surface** is pulled by a rope with tension $T = 50\ N$, as shown. The coefficient of kinetic friction between the block and surface is $\mu_k = 0.3$.

a. **Draw a free body diagram for the block.**





b. **Find the magnitude of the normal force exerted by the surface on the block.**

$$n + T \sin(36.9^o) - mg = 0$$

$$n = mg - T \sin(36.9^o) = 12(10) - 50 \sin(36.9^o) = 90\ N$$

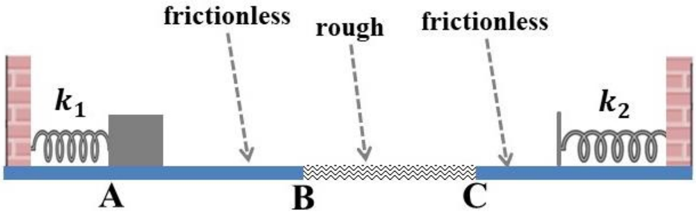
c. **Find the acceleration of the block.**

$$T \cos\ (36.9^o) - f_k = ma$$

$$T \cos\ (36.9^o) - \mu_k n = ma$$

$$a = \frac{T \cos\ (36.9^o) - \mu_k n}{m} = 1.1\ m/s^2$$

LP2 A 2 kg block initially compresses a spring of force constant $k_1 = 1800\ N/m$ a distance of $x_1 = 0.2$ m before being released **from rest at point A**. The block then leaves the spring and slides along a frictionless track until point B, then **rough between points B and C**. Finally, it compresses another spring of force constant $k_2 = 5000\ N/m$ **<u>a maximum</u> distance** of $x_2 = 0.1\ m$.



a. **Find the speed of the block when it reaches point B.**

$$\frac{1}{2}k_1x_1^2 = \frac{1}{2}mv_B^2 \Rightarrow v_B = \sqrt{\frac{k_1}{m}x_1^2} = 6\ m/s$$

b. **Find the speed of the block when it reaches point C.**

$$\frac{1}{2}k_2x_2^2 = \frac{1}{2}mv_C^2 \Rightarrow v_C = \sqrt{\frac{k_2}{m}x_2^2} = 5\ m/s$$

c. **Find the work done on the block by friction between points B and C**

$$w_{f_k} = \frac{1}{2}k_2x_2^2 - \frac{1}{2}k_1x_1^2$$

$$= \frac{1}{2}(5000)\ (0.1^2) - \frac{1}{2}(1800)\ (0.2^2) = -11\ J$$

OR

$$w_{f_k} = \frac{1}{2}m\ (v_c^2 - v_B^2) = \frac{1}{2}\ (2)(5^2 - 6^2) = -11\ J$$

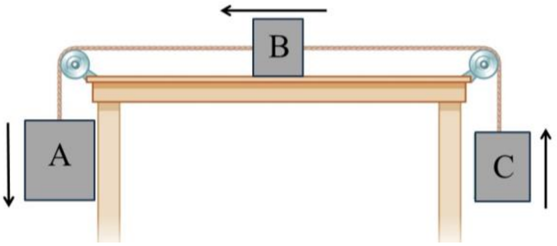
Part III: Questions (Choose the correct answer, one point each)

Q1. A book is stationary on a flat, horizontal table. The **reaction force to the book's weight is**:

* the gravitational force exerted by the book on the Earth.
* the gravitational force exerted by the table on the book.
* the normal force exerted by the Earth on the book.
* the normal force exerted by the table on the book.

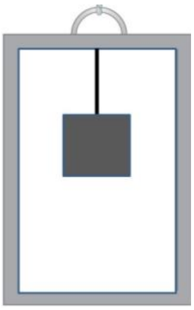
Q2. Three masses A, B, and C are connected by a system of massless pulleys and light strings and move as shown in the figure. The **work done by the force of gravity on masses A, B, and C respectively** is

* negative, negative, positive
* positive, positive, negative
* negative, zero, positive
* positive, zero, negative



Q3. A block is suspended from the ceiling of an elevator by a rope, as shown. **If the tension in the rope is greater than the block's real weight**, then the elevator moves

* upward with decreasing speed
* downward with decreasing speed
* downward with increasing speed
* upward with constant speed



Q4. Consider the path ABCA shown in the figure. If the work done by a conservative force $\vec{F}$ from A to B is 9 J, and the work done by $\vec{F}$ from B to C is 12 J, **then the work done by $\vec{F}$ from C to A is**:

* $-15\,J$
* $21\,J$
* $-21\,J$
* $0\,J$