Kuwait University Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Spring Semester
Second Midterm Exam
Saturday, April 29, 2023
9:00 AM – 10:30 AM

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

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

Choose your Instructor's Name:

Dr. Abdulmuhsen Ali	Dr. Abdul Khaleq
Dr. Tareq Alrefai	Dr. Nasser Demir
Dr. Fatema Al Dosari	Dr. Ruqayyah Askar
Dr. Belal Salameh	Dr. Bedoor Alkurtass

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

Part I: Short Problems (2 points each)

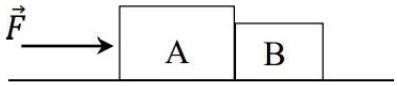
SP1. The velocity of a $4\,kg$ object moving in the xy plane as a function of time is given by $\vec{v} = [3t^3\hat{\imath} - (7 + t^2)\hat{\jmath}]$ m/s, where t is measured in seconds. **Find the net force on the object in unit vector notation at $t = 2$ s**.

$\vec{a} = \frac{d\vec{v}}{dt} = [9t^2\hat{\imath} - 2t\,\hat{\jmath}]$ m/s^2

$\vec{a}(t = 2s) = \frac{d\vec{v}}{dt} = [9(2)^2\hat{\imath} - 2(2)\,\hat{\jmath}]$ m/$s^2 = (36\,\hat{\imath} - 4\,\hat{\jmath})$ m/s^2

$\vec{F}_{net} = m\vec{a} = (144\hat{\imath} - 16\hat{\jmath})N$

SP2. Blocks A and B ($m_A = 30\,kg$ and $m_B = 10\,kg$) are in contact on a horizontal **frictionless surface**. A horizontal force $F = 120\,N$ is exerted on block A, as shown. **What is the magnitude of the force that block B exerts on block A?**



$F = (m_A + m_B)a \Rightarrow a = \frac{F}{(m_A + m_B)} = \frac{120}{40} = 3\,m/s^2$

$F_{BA} = F_{AB} = m_B a = 10(3) = 30\,N$

SP3. A $0.5\,kg$ block is moving with a velocity of $3\,m/s$ along **a frictionless**, horizontal surface toward a spring with force constant $k = 450\,N/m$ which is attached to a wall. **Find the maximum distance the spring will be compressed.**

$E_i = E_f$

$\frac{1}{2}mv_i^2 = \frac{1}{2}kx_f^2$

$(0.5)(3)^2 = (450)x_f^2 \Rightarrow x_f = 0.1\,m$

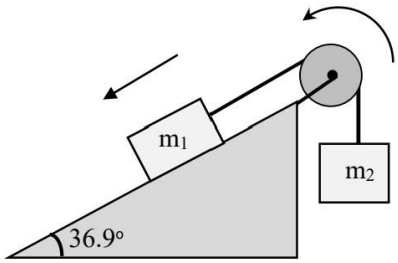
SP4. An elevator has a mass of 900 kg is carrying passengers having a combined mass of 300 kg. A constant **friction force** of 5000 N acts on the elevator. **What power delivered by the motor is required to lift the elevator upward at <u>a constant speed</u> of 2 m/s?**

$\Sigma F_y = T - mg - f_k = 0$

$T = mg + f_k = (900 + 300)(10) + 5000 = 17000N$

$P = Tv = (17000)(2) = 34000\ W$

SP5. Two blocks are connected to a light rope passing over a massless, frictionless pulley, as shown. If the inclined surface is **frictionless,** find the ratio $\boldsymbol{m_1/m_2}$ such that the blocks move **<u>with constant velocity</u>**.



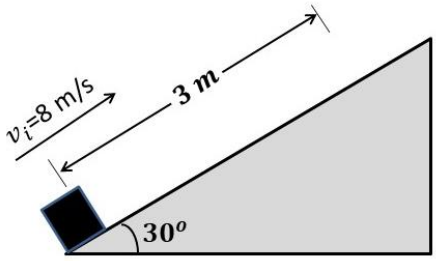
$\sum F_x = 0$

$m_1 g \sin(36.9^o) - m_2 g = 0$

$m_1 \sin(36.9^o) = m_2 \ \Rightarrow \dfrac{m_1}{m_2} = \dfrac{1}{\sin(36.9^o)} = 1.67$

Part II: Long Problems (3 points each)

LP1. A 5 kg block is set into motion up an inclined plane with an initial speed of 8 m/s, as shown. The block **comes to rest** after traveling 3 m along the plane.



a) Find the change in the block's kinetic energy.

$$\Delta K = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

$$= 0 - \frac{1}{2}(5)(8)^2 = -160J$$

b) Find the change in the gravitational potential energy.

$\Delta y = d\sin\theta = 3\sin 30° = 1.5m$

$\Delta U_g = mg\Delta y = (5)(10)(1.5) = 75J$

c) Find the magnitude of the friction force exerted on the block (assumed to be constant).

$W_{f_k} = \Delta K + \Delta U_g = -160 + 75 = -85J$

$W_{f_k} = -f_k d = -3f_k = -85$

$\Longrightarrow f_k = 28.3N$

OR

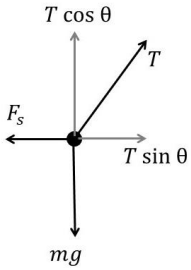
$v_{xf}^2 = v_{xi}^2 + 2a(\Delta x) \quad \Rightarrow \quad a = \frac{v_{xf}^2 - v_{xi}^2}{2\Delta x} = \frac{0 - 8^2}{6} = -10.67\ m/s^2$

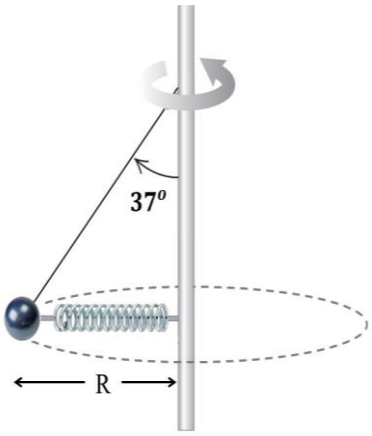
$F_{net} = ma = mg\sin(30^o) + f_k$

$\Rightarrow f_k = ma - mg\ sin\ (30^o) = 5(10.67) - 5(10)(0.5) = 28.3\ N$

LP2. A ball of mass $m = 0.4\,kg$ is attached to a light rope and a spring, as shown. The ball rotates in a horizontal circle of radius $R = 3\,m$ with a constant speed of $v = 2\,m/s$. **The spring is <u>compressed</u> a distance $x = 0.2\,m$.**

a) Draw a free body diagram for the ball.





b) Find the tension in the rope.

$$T\cos\theta = mg \Rightarrow T = \frac{mg}{\cos\theta} = \frac{4}{\cos(37^o)} = 5\ N$$

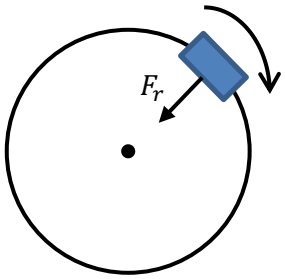
c) Find the value of the spring constant k.

$$T\sin\theta - kx = m\frac{v^2}{R} \Rightarrow k = \frac{1}{x}\left(T\sin\theta - m\frac{v^2}{R}\right) = 12.4\ N/m$$

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

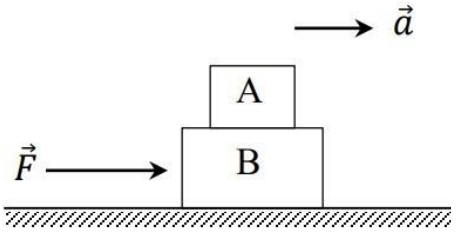
Q1. The work done by a centripetal force (F_r) on an object moving in a circle at constant speed is:

* zero.
* equal to the force exerted on it.
* equal to the kinetic energy of the object.
* equal to the force exerted multiplied by the displacement.



Q2. An applied force accelerates block B towards the right, as shown. Block A, which does not slip with respect to block B, also accelerates to the right. **The direction of the static friction between the two blocks is**

* to the right on both A and B.
* to the left on both A and B.
* to the right on A, to the left on B.
* to the left on A, to the right on B.



Q3. A man stands on a scale in an elevator. If the man's **apparent weight is less than his real weight, then the elevator moves**

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

Q4. A box slides down an incline at **constant speed**. Which of the following statements is true?

* Friction acting on the block is negligible.
* Mechanical energy is conserved in this system.
* Mechanical energy is not conserved in this system.
* The weight of the box equals the frictional force.