Kuwait University Physics Department

Physics 101

Spring Semester

Final Exam

Monday, July 05, 2021

2:00 pm – 4:00 pm

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

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

Choose your Instructor's Name:

Dr. Ahmed Al-Jassar
Dr. Hala Al-Jassar
Dr. Fatema Al Dosari
Dr. Nasser Demir
Dr. Tareq Al Refai
Dr. Abdul Khaleq
Dr. Belal Salameh

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	SP5	SP6	SP7	LP1	LP2	LP3	Q1	Q2	Q3	Q4	Total
Pts	3	3	3	3	3	3	3	5	5	5	1	1	1	1	40

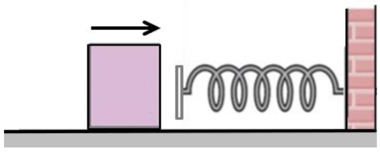
Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 40 points as arranged in the above table.
3. **Give your final answer in the correct units.**
4. Assume g = 10 m/s^2 (acceleration due to gravity on the earth).
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 (3 points each)

SP1. A 4 Kg block moving on **a horizontal rough surface** ($\mu_k = 0.6$) hits a relaxed spring with speed of 2 m/s as shown. **If the maximum compression of the spring is $0.2\ m$, find the force constant of the spring (k).**



$$E_f - E_i = -\mu_k mgd$$

$$\frac{1}{2}kd^2 - \frac{1}{2}mv_i^2 = -\mu_k mgd$$

$$k = \frac{mv_i^2 - 2\mu_k mgd}{d^2} = \frac{(4)(2^2) - 2(0.6)(4)(10)(0.2)}{0.2^2} = 160\ N/m$$

Answer: $k = 160\ N/m$

SP2. Ball A ($m_A = 2\ kg$) collides elastically with ball B ($m_B = 4\ kg$). The initial kinetic energy of ball A is 60 J and of ball B is 90 J. After the collision, both balls have the same speed and move in different directions. **Find the kinetic energy of ball A after the collision.**

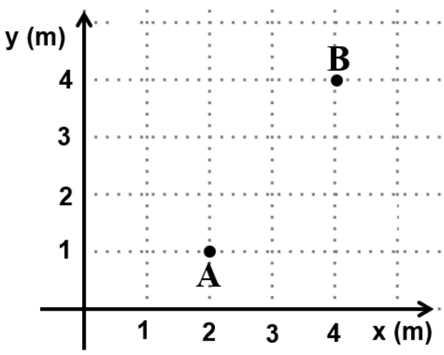
$$\sum K_i = \sum K_f$$

$$150\ J = \frac{1}{2}(2)v_f^2 + \frac{1}{2}(4)v_f^2 = 3v_f^2 \Rightarrow v_f^2 = 50$$

$$K_{A_f} = \frac{1}{2}(2)v_f^2 = 50\ J$$

Answer: $K_{A_f} = 50\ J$

SP3. **Find the work done by the conservative force** $\vec{F} = \left(6\hat{\imath} + 3\hat{\jmath} - 5\hat{k}\right) N$ to move a 3 kg block from point A to point B (see the figure).



$$\Delta\vec{r} = \vec{r}_B - \vec{r}_A = (4-2)\hat{\imath} + (4-1)\hat{\jmath} = (2\hat{\imath} + 3\hat{\jmath})\ m$$

$$W_F = \vec{F}\cdot\Delta\vec{r} = \left(6\hat{\imath} + 3\hat{\jmath} - 5\hat{k}\right)\cdot(2\hat{\imath} + 3\hat{\jmath}) = 21\ J$$

Answer: $W_F = 21\ J$

SP4. A particle of mass $m_1 = 0.1$ kg moving with velocity $\vec{v}_1 = (6\hat{\imath} + 5\hat{\jmath})\ m/s$ collides with another particle of mass $m_2 = 0.2$ kg moving with velocity $\vec{v}_2 = (3\hat{\imath} - 7\hat{\jmath})\ m/s$. After the collision, the two particles **<u>stick together</u>**. **What is the speed of the combined particles after the collision?**

$$\sum \vec{p}_i = \sum \vec{p}_f$$

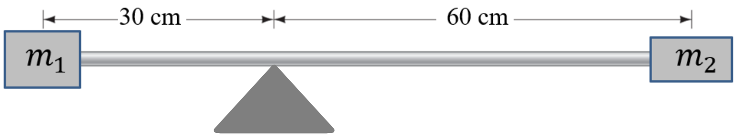
$$m_1\vec{v}_{1_i} + m_1\vec{v}_{2_i} = (m_1 + m_2)\vec{v}_f$$

$$\vec{v}_f = \frac{m_1\vec{v}_{1_i} + m_1\vec{v}_{2_i}}{(m_1 + m_2)} = \frac{0.1(6\hat{\imath} + 5\hat{\jmath}) + 0.2(3\hat{\imath} - 7\hat{\jmath})}{0.3} = (4\,\hat{\imath} - 3\hat{\jmath})m/s$$

$$v_f = \sqrt{4^2 + (-3)^2} = 5\ m/s$$

Answer: $v_f = 5\ m/s$

SP5. Two blocks ($m_1 = 6\ kg, m_2 = 4\ kg$), are attached to the ends of **a massless rod** which pivots as shown. Initially the rod is held in the horizontal position and then released. **Calculate the magnitude and direction of the initial net torque on the system.**



$$\tau_{net} = m_1 g r_1 - m_2 g r_2$$

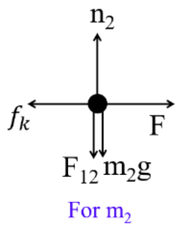
$$= 60(0.3) - 40(0.6) = -6\ N\cdot m$$

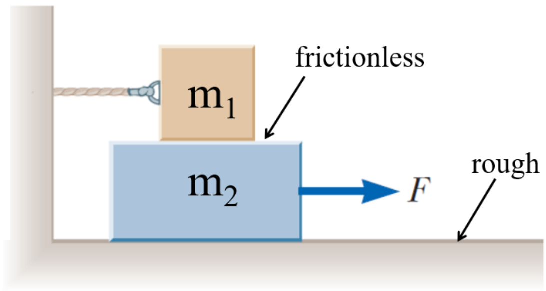
$$|\tau_{net}| = 6\ N\cdot m, \text{into the page}$$

Answer: $|\tau| = 6\ N\cdot m$, into the page

SP6. Block 1 ($m_1 = 5\ kg$) is tied to a wall and is placed on top of block 2 ($m_2 = 10\ kg$). A horizontal force $F = 45\ N$ is applied to block 2 as shown. **The coefficient of kinetic friction between the floor and block 2 is $\boldsymbol{\mu_k = 0.2}$ and the surface between the two blocks is frictionless. Find the acceleration of block 2.**

$$f_k = \mu_k (m_1 + m_2) g = 30\ N$$
$$F - f_k = m_2 a$$
$$a = \frac{F - f_k}{m_2} = 1.5\ m/s^2$$

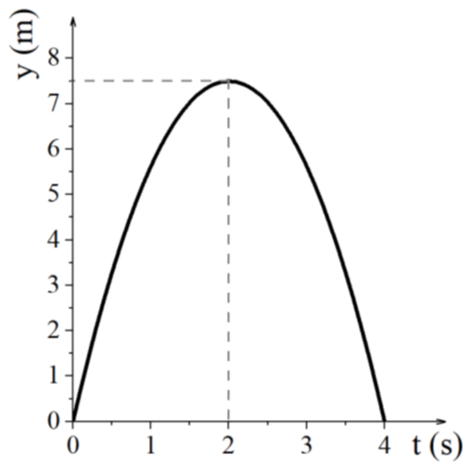




Answer: $a = 1.5\ m/s^2$

SP7. An object is in free-fall motion on Mars. Calculate the **acceleration due to gravity on Mars,** given the relation between **<u>its height (y) and time (t)</u>**, as shown in the figure.

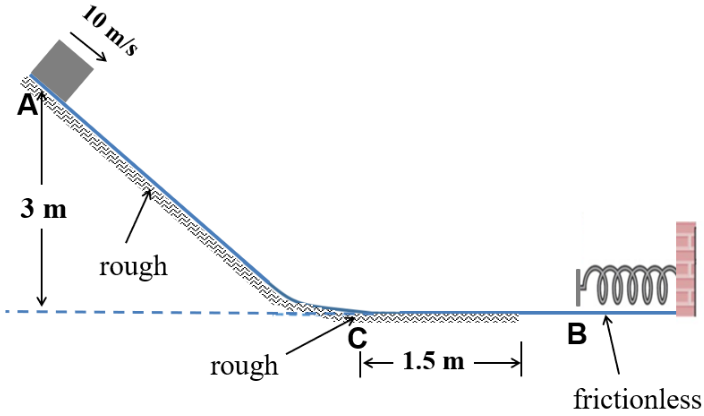
$$v_{y_f} = v_{y_i} - g't \Rightarrow 0 = v_{y_i} - 2\ g' \Rightarrow v_{y_i} = 2\ g'$$
$$\Delta y = v_{y_i} t - \frac{1}{2} g' t^2$$
$$7.5 = (2\ g')(2) - \frac{1}{2} g' (2)^2 \Rightarrow g' = 3.75\ m/s^2$$



Answer: $g' = 3.75\ m/s^2$

Part II: Long Problems (5 points each)

LP1. A block ($m = 2\ kg$) is projected from point A with a speed of $10\ m/s$ and strikes a relaxed spring at point B with speed of $3\ m/s$. The block compresses the spring a maximum distance of $0.2\ m$ and moves back and stops at point C.



a) Find the force constant of the spring (k).

$$\frac{1}{2}mv_B^2 = \frac{1}{2}kx_{max}^2$$

$$k = \frac{mv_B^2}{x_{max}^2}$$

$$= \frac{2(3)^2}{0.2^2} = 450\ N/m$$

Answer: $k = 450\ N/m$

b) Find the magnitude of the frictional force on the block along the horizontal surface.

$$v_C^2 = v_B^2 + 2a\Delta x \Rightarrow 0 = 3^2 + 3a \Rightarrow a = -3m/s^2$$

$$|f_k| = m|a| = 6\ N$$

OR

$$\frac{1}{2}mv_B^2 = |f_k|d \Longrightarrow |f_k| = \frac{mv_B^2}{2d} = 6\ N$$

Answer: $|f_k| = 6\ N$

c) Find the work done by gravity on the block between points A and C.

$$W_{mg} = mgh = (2)(10)(3) = 60\ J$$

Answer: $W_{mg} = 60\ J$

d) Find the total work done <u>by friction</u> on the block.

$$E_C - E_A = W_{f_k}$$

$$W_{f_k} = 0 - \left(\frac{1}{2}mv_A^2 + mgh\right) = -160\ J$$

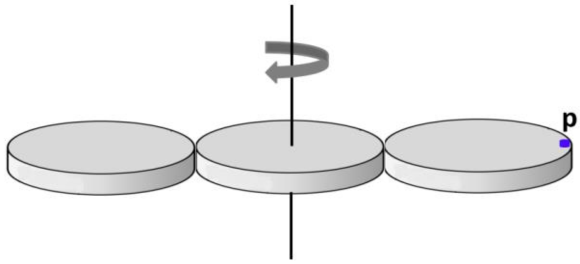
Answer: $W_{f_k} = -160\ J$

LP2. A system of three identical circular disks, each of mass M and radius $R = 0.2\ m$ are welded together ($I_{system} = 1.14\ kg \cdot m^2$). The system starts to rotate **from rest** about an axis passing through the center of the middle disk with constant angular acceleration of $2\ rad/s^2$ as shown.

a) Find the kinetic energy of the system at $t = 10\ s$.

$\omega_f = \omega_i + \alpha t = 0 + 2(10) = 20\ rad/s$

$K = \frac{1}{2} I\omega^2 = \frac{1}{2}(1.14)(20^2) = 228\ J$



Answer: $K = 228\ J$

b) How many revolutions does the system make in the first 10 s.

$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2 = 0 + \frac{1}{2}(2)(10^2) = 100\ rad = \left(\frac{100}{2\pi}\right) rev = 15.9\ rev$

Answer: $\Delta\theta = 15.9\ rev$

c) Calculate the linear speed of <u>point p</u> at the rim of the first disk at $t = 10\ s$.

$v = r\omega = 3R\omega = 0.6(20) = 12\ m/s$

Answer: $v = 12\ m/s$

d) Find the mass of each disk. (for each disk: $I_{cm} = \frac{1}{2}MR^2$)

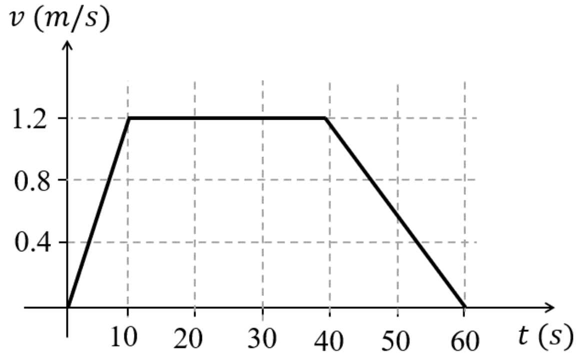
$I_{system} = I_{cm} + 2[I_{cm} + M(2R)^2]$

$1.14 = \frac{1}{2}MR^2 + 2\left[\frac{1}{2}MR^2 + 4MR^2\right] = 9.5MR^2$

$1.14 = 9.5M(0.2)^2 \Rightarrow M = 3\ kg$

Answer: $M = 3\ kg$

LP3. A man starts pushing a $50\ kg$ box at $t = 0\ s$ along a straight line on **a rough** horizontal surface. At $t = 40\ s$ the man removes his hand and the box slides to stop at $t = 60\ s$. The velocity of the box as a function of time is shown in the figure.



a) Find the total distance covered by the box

$$d = Area = \frac{1}{2}(10)(1.2) + (30)(1.2) + \frac{1}{2}(20)(1.2) = 54\ m$$

Answer: $d = 54\ m$

b) Calculate the acceleration of the box when $t > 40\ s$.

$$a = slope = \frac{-1.2}{20} = -0.06\ m/s^2$$

Answer: $a = -0.06\ m/s^2$

c) Find the force of friction on the box.

between $t = 40\ s$ and $t = 60\ s$: $\sum F = f_k = ma = 50(-0.06) = -3\ N$

Answer: $f_k = -3\ N$

d) Find the work done by the man on the box between $t = 0\ s$ and $t = 60\ s$.

$$\sum W = \Delta K = 0$$

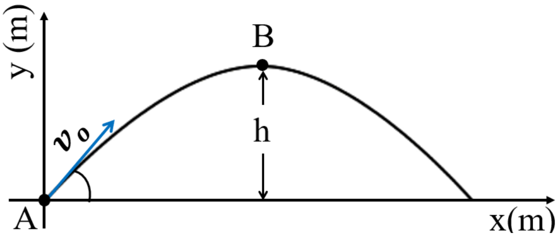
$$W_{man} + W_{f_k} = 0 \Rightarrow W_{man} = -W_{f_k} = f_k d = 3(54) = +162\ J$$

Answer: $W_{man} = +162\ J$

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

Q1. A stone of mass m is projected from point A with speed v_o and moves along the trajectory, as shown. **The total mechanical energy <u>at point B</u> is: (ignore air resistance)**

* $\frac{1}{2}mv_o^2 + mgh$
* mgh
* $\frac{1}{2}mv_o^2 - mgh$
* $\frac{1}{2}mv_o^2$

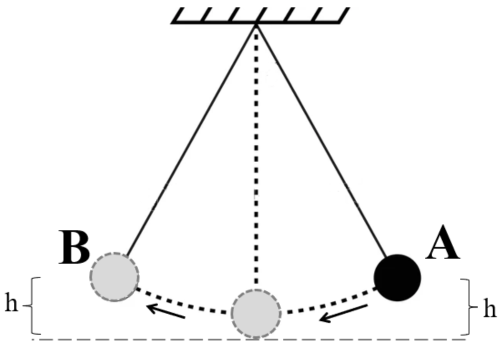


Q2. If an object is **in equilibrium**, which of the following statements **<u>is not true</u>**?

* The velocity of the object is constant.
* The acceleration of the object is zero.
* The net force acting on the object is zero.
* The object must be at rest.

Q3. Consider the simple pendulum shown in the figure. As the bob moves from point A to point B, **the work done on the bob by gravity and by tension, respectively are:**

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



Q4. A disc is rotating clockwise about the y-axis as viewed from above with **<u>a decreasing</u>** speed. **The direction of the angular acceleration is:**

* $+\hat{k}$
* $-\hat{k}$
* $+\hat{j}$
* $-\hat{j}$