Kuwait University **Physics Department**

Physics 101

Fall Semester

Final Exam

Saturday, December 22, 2018

02:00 pm – 04:00 pm

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

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

Choose your Instructor's Name:

Prof. Yacoub Makdisi
Dr. Ahmed Al-Jassar
Dr. Hala Al-Jassar
Dr. Nasser Demir
Dr. Abdul Mohsen
Dr. Tareq Al Refai
Dr. Belal Salameh
Dr. Abdel Khaleq

Grades: **For Instructors use only**

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

Important:

1. Answer all questions and problems.
2. Full mark = 40 points arranged in the above table.
   i) 4 **Q**uestions.
   ii) 7 **S**hort **P**roblems.
   iii) 3 **L**ong **P**roblems.
3. No solution = no points.
4. **Use SI units.**
5. Select the correct answer for each question.
6. Assume $g = 10\ m/s^2$.
7. Mobiles are **strictly prohibited** during the exam.
8. Programmable calculators, which can store equations, are not allowed.
9. **Please write down your final answer in the box shown in each problem.**
10. **Cheating incidents will be processed according to the university rules.**

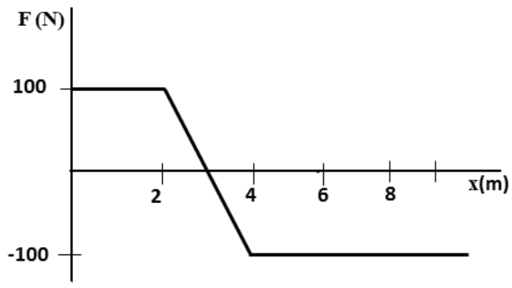
GOOD LUCK

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

Q1. Under which of the following conditions is $|\vec{A} - \vec{B}| = |\vec{A} + \vec{B}|$?

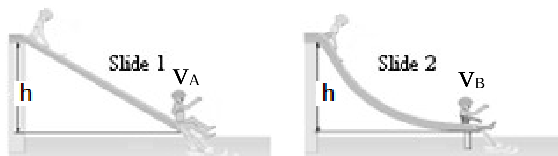
* always
* (*) if $\vec{A}$ is perpendicular to $\vec{B}$
* if $\vec{A}$ is parallel to $\vec{B}$
* if $\vec{A}$ is anti parallel to $\vec{B}$

Q2. The graph shows the **net force** exerted on a particle moving along the x direction as a function of its position. If the particle's **speed** at x = 0 is ($\mathbf{v_i}$), **at what other position does it have the same initial speed?**



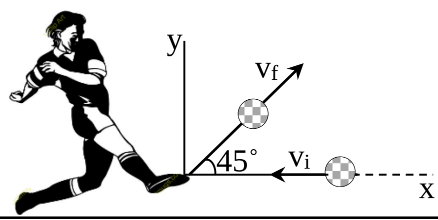
* x = 2
* x = 4
* (*) x = 6
* x = 8

Q3: Ali ($M_A = 20$ Kg) and Bader ($M_B = 15$ Kg) slide from rest on two **frictionless slides** as shown in the figure. **Both slides have the same height, *h*.** At the slides end, their speeds are v_A and v_B , respectively. Which of the following statements is correct?



* $v_A > v_B$
* $v_A < v_B$
* (*) $v_A = v_B$
* No simple relation between v_A and v_B because we don't know the curvature of slide 2

Q4. A soccer ball initially is moving to the left with a speed $v_i \neq 0$, but then it is kicked. After the kick it is moving at 45° upward with a speed v_f, as shown in the figure. **The angle (α) between <u>the average net force</u> on the ball and the x-axis is:**



* α = 0°
* (*) 0° < α < 45°
* α = 45°
* α = 90°

Part II: Short Problems (3 points each)

SP1. The angular velocity of a wheel rotating about z-axis is $-4\ rad/s$ at $t = 0$ and increases **linearly** with time to $6\ rad/s$ at t=5 s. **Find the angular displacement ($\Delta\theta$) during this time period.**

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{6 - -4}{5} = 2\ rad/s^2$$

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2 = -4(5) + \frac{1}{2}(2)(5)^2 = 5\ rad$$

<u>OR</u>

$$\Delta\theta = \left(\frac{\omega_i + \omega_f}{2}\right)\Delta t$$

$$= \left(\frac{-4 + 6}{2}\right)5 = 5\ rad$$

Answer: $\Delta\theta = 5\ rad$

SP2. A particle moves under the influence of **a single conservative force** with a potential energy of $U = 2x^2 - 5x$, where U is in J and x is in m. **Find the position of the particle when it is at equilibrium**.

$$F = -\frac{dU}{dx} = -4x + 5$$

$$F = 0 \;\; \Rightarrow \;\; -4x + 5 = 0$$

$$x = 1.25\ m$$

Answer: $x = 1.25\ m$

SP3. A 4 kg object has an initial velocity of $6\hat{\imath}\ m/s$. **Find the total work done on the object** if its velocity changes to $4\hat{\jmath}\ m/s$.

$$W = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$v_i^2 = 36\ (\frac{m}{s})^2$$

$$v_f^2 = 16\ (\frac{m}{s})^2$$

$$W = \frac{1}{2}4[16 - 36] = -40\ J$$

Answer: $W = -40\ J$

SP4. A block at the bottom of **a frictionless** incline is given **an initial velocity of 4 m/s up the incline** as shown in the figure. **How far up the incline (d) does the block reach before coming to rest momentarily**?

$$F = -m\,g\sin\theta = ma$$

$$a = -g\sin\theta = -5\ m/s^2$$

$$v_f^2 = v_i^2 + 2a(d)$$

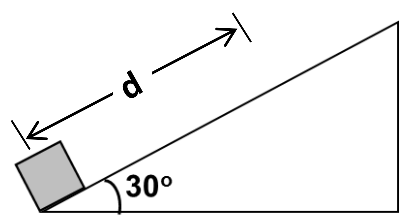
$$d = \frac{0-16}{-10} = 1.6\ m$$

OR

$$E_i = E_f$$

$$\frac{1}{2}mv_i^2 = m\,g\,h = m\,g\,(d\sin\theta)$$

$$d = \frac{v_i^2}{2\,g\sin\theta} = 1.6\ m$$

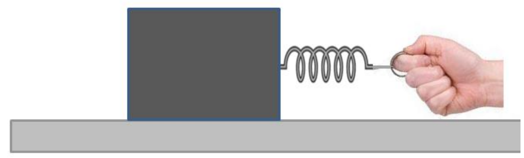


Answer: $d = 1.6\ m$

SP5. A 15 kg block rests on a rough horizontal surface ($\mu_s = 0.6, \mu_k = 0.4$). The block is connected to a spring ($k = 300\ N/m$). A gradually increasing force is applied to the spring. **At the moment just before the block starts to move, find the potential energy stored in spring.**

$$kx = \mu_s mg \Rightarrow x = \frac{\mu_s mg}{k} = \frac{(0.6)(15)(10)}{300} = 0.3\ m$$

$$U_{el} = \frac{1}{2}kx^2 = \frac{1}{2}(300)(0.3^2) = 13.5\ J$$

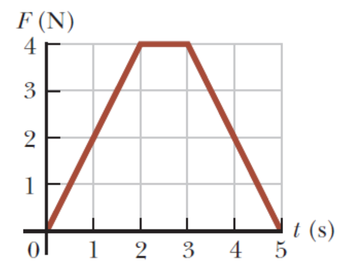


Answer: $U_{el} = 13.5\ J$

SP6. The magnitude of **the net force** exerted along the x direction on a 0.5 kg box varies with time as shown in the figure. **Find the speed of the box at $t = 5\ s$ if it starts moving to the right at a speed of 2 m/s at $t = 0\ s$.**

$$\Delta p = m(v_f - v_i) = Area = \frac{1}{2}(2)(4) + (1)(4) + \frac{1}{2}(2)(4) = 12\ kg\ m/s$$

$$v_f = \frac{\Delta p}{m} + v_i = \frac{12}{0.5} + 2 = 26\ m/s$$



Answer: $v_f = 26\ m/s$

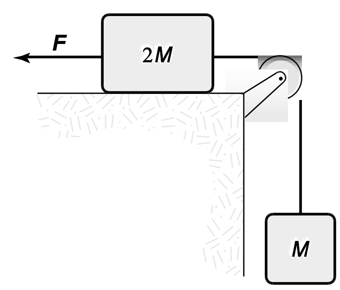
SP7. In the figure shown, assume that all surfaces are **frictionless and the <u>pulley is massless</u>**. If $F = 50\ N$ and $M = 2\ kg$, **what is the tension in the string connecting M and 2M?**

$$F - Mg = 3Ma$$

$$a = \frac{F - Mg}{3M} = \frac{50 - 20}{6} = 5\ m/s^2$$

$$T - Mg = Ma$$

$$T = M(g + a) = 30\ N$$



Answer $T = 30\ N$

Part III: Long Problems (5 points each)

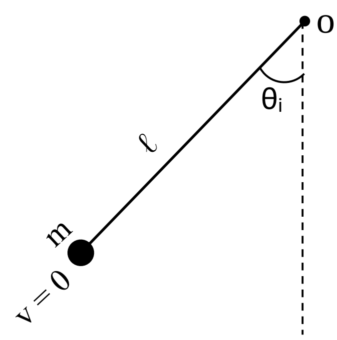
LP1. A simple pendulum made of **a massless string** of length (l) and **a small** ball of mass (m), starts from **rest** at ($\theta = \theta_i$).

a) Find the speed of the ball (in terms of m, ℓ and θ_i**) when the pendulum is at the vertical position (θ = 0°).**

$E_i = E_f$

$mgl(1 - cos\theta) = \frac{1}{2}mv^2$

$v = \sqrt{2gl(1 - cos\theta_i)}$



Answer: $v = \sqrt{2gl(1 - cos\theta_i)}$

b) Find the rotational kinetic energy (in terms of m, ℓ and θ_i**) at the vertical position.**

Hint: treat the ball as a point mass.

$K = \frac{1}{2}I\omega^2$

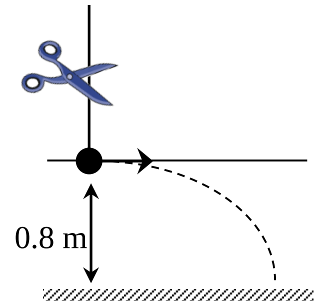
$K = \frac{1}{2}(ml^2)(\frac{v}{l})^2 = \frac{1}{2}mv^2 = mgl(1 - cos\theta_i)$

Answer: $K = mgl(1 - cos\theta_i)$

c) If the string is cut at the vertical position when the ball is at 0.8 m above the ground, find the y-component of the velocity when it hits the ground.

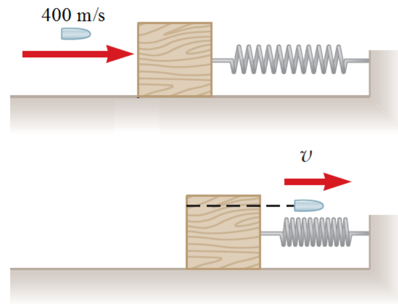
$v_{yf}^2 = v_{yi}^2 - 2g(\Delta\, y)$

$v_{yf} = \sqrt{-2g(\Delta\, y)} = \sqrt{-2(10)(-0.8)} = -4\; m/s$



Answer: $v_{yf} = -4\; m/s$

LP2. A bullet of mass $m = 5\ g$ moving with a speed of $v_i = 400\ m/s$ is fired into and passes through a block of mass $M = 1\ kg$, as shown in the figure. The block which is **initially at rest** on a **frictionless** surface is connected to a spring with force constant $k = 900\ N/m$. The block moved a distance $d = 5\ cm$ to the right after the impact before being brought momentarily to rest by the spring. **Assume that the collision time is very small.**



a) **Find the maximum speed of the block (just after the bullet emerges from it).**

$$\frac{1}{2}MV_i^2 = \frac{1}{2}kx^2$$

$$V_i = \sqrt{\frac{k(x)^2}{M}} = \sqrt{\frac{900(0.05)^2}{1}} = 1.5\ m/s$$

Answer: $V_i = 1.5\ m/s$

b) **Find the compression of the spring (x) when the speed of the block is ($0.5\ m/s$).**

$$\frac{1}{2}MV_i^2 = \frac{1}{2}MV^2 + \frac{1}{2}kx^2$$

$$\frac{1}{2}(1)(1.5)^2 = \frac{1}{2}(1)(0.5)^2 + \frac{1}{2}(900)x^2$$

$$x = 0.047\ m$$

Answer: $x = 0.047\ m$

c) **Find the bullet speed after emerging from the block.**

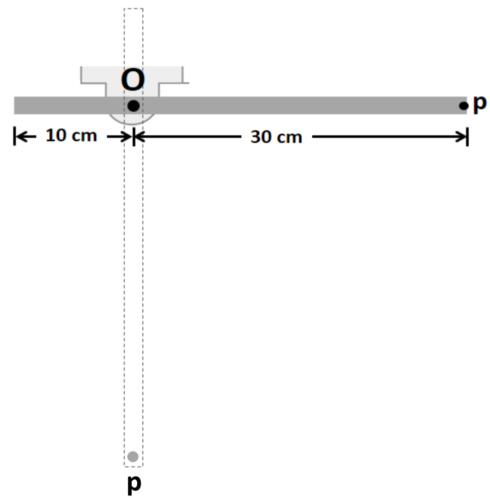
$$mv_i + 0 = MV + mv_f$$

$$v_f = \frac{mv_i - MV}{m} = \frac{0.005(400) - 1(1.5)}{0.005} = 100\ m/s$$

Answer: $v_f = 100\ m/s$

LP3. A uniform rod of length $l = 40\ cm$ and mass M = 1.5 kg is attached to **a frictionless** pivot (point O) and is free to rotate about the pivot in the vertical plane as shown in the figure. **The rod is released from rest when it is in the horizontal position**. The moment of inertial of the rod about its center of mass is: $I_{CM} = \frac{1}{12}Ml^2 = 0.02\ \text{kg m}^2$.

a) What is the moment of inertia of the rod about the point O?



$I_O = I_{CM} + Md^2$

$I_O = 0.02 + (1.5)(0.1)^2 = 0.035\ \text{kgm}^2$

Answer: $I_O = 0.035\ kgm^2$

b) What is the angular speed of the rod when it is in the vertical position?

$E_i = E_f$

$mgh = \frac{1}{2}I\omega^2$

$$\omega = \sqrt{\frac{2mgh}{I}} = \sqrt{\frac{2(1.5)(10)(0.1)}{0.035}} = 9.26\ \text{rad/s}$$

Answer: $\omega = 9.26\ rad/s$

c) What is the linear speed of the point P when the rod is in the vertical position?

$v = R\omega = (0.3)(9.26) = 2.78\ \text{m/s}$

Answer: $v = 2.78\ \text{m/s}$