Kuwait University — Physics Department

Physics 101

Spring Semester
2nd Midterm Exam
Saturday, April 29, 2017
9:00 a. m. – 10:30 a.m.

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

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

Choose your Instructor's Name:

Prof. Yacoub Makdisi	Dr. Abdul Mohsen
Dr. Hasan Raafat	Dr. Tareq Al Refai
Dr. Hala Al-Jassar	Dr. Belal Salameh
Dr. Ahmed Al-Jassar	Dr. Nasser Demir
Dr. Fatema Al Dosari	Dr. Abdul Khaleq

For Instructors use only

Grades:

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

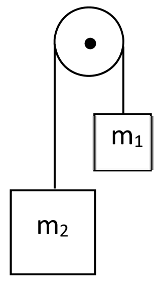
Important:

1. No solution = no points.
2. No units = no points.
3. Assume g = 10 m/s^2.
4. **Please write down your final answer in the box shown in each problem**.
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: Questions (circle the * of the right answer) (1 point each)

Q1. Two masses m_1 and m_2 with $m_2 > m_1$ are connected via a light rope over a massless pulley, as shown in the figure. They are then released from rest. The **work done by gravity** on m_1 and m_2, respectively, is

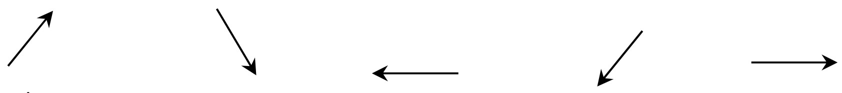


* positive, positive
* negative, negative
* positive, negative
* negative, positive
* zero, zero

Q2. A constant force F is applied to a block on a horizontal surface, which is shown in the figure. Which of the following directions of F will result in the **greatest magnitude** of the normal force exerted by the surface?

* * * * *

Q3. A ball of mass m attached to a light rope rotates in a **vertical circle**, as shown in the figure. Which of the following vectors denotes the direction of the **net force** acting upon the ball at point P?



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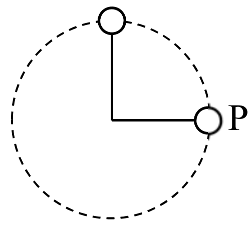
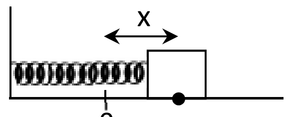


Q4. A block attached to a spring is pulled from its equilibrium position at point O a distance x to point A, then released from rest. The block slides on a frictionless surface. Which of the following is true as the block passes point O?



* v =0, a = 0
* v = 0, a is at a maximum
* v and a are both at a maximum
* v is at a maximum, a = 0
* v and a are both at constant throughout the motion

Part II: Short Problems (2 points each)

SP1. A constant force $\vec{F} = (30\hat{\imath} - 40\hat{\jmath})$ N acts on a particle that undergoes a displacement of $\Delta\vec{r} = (-8\hat{\imath} + 10\hat{\jmath})$ m. **Find the average power delivered by $\vec{F}$ during the first 5 seconds.**

$$P_{av} = \frac{W}{\Delta t}$$

$$W = \vec{F} \cdot \Delta\vec{r} = 30(-8) + (-40)(10) = -640\,J$$

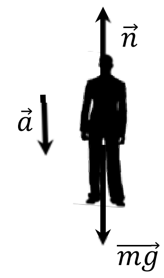
$$P_{av} = \frac{-640}{5} = -128\,watts$$

Answer: $-128\,watts$

SP2. A man of mass 80 kg rides in an elevator initially moving upward at 4.0 m/s, which slows to a stop uniformly with an acceleration of magnitude 0.5 m/s^2. **Find the apparent weight of the man.**

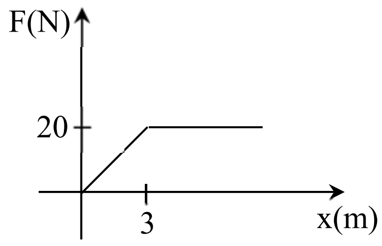
$mg - n = ma$

n$= m(g - a) = 80(10 - 0.5) = 760\ N$



Answer: $760\ N$

SP3. A variable force acting along the x-axis is shown in the figure. It acts upon an object of mass m = 4.0 kg. If the speed of the object at the origin is 2 m/s in the +x direction, **find the speed of the object when it is at the position x = 4 m.**



$W_{tot} = \Delta K$

$\frac{1}{2}(3)(20) + 20(1) = \frac{1}{2}\ mv_f^2 - \frac{1}{2}\ mv_i^2$

$50 = 2v_f^2 - 2(2)^2$

$\Rightarrow\ v_f = \sqrt{29}\ m/s \approx 5.4\ m/s$

Answer: $5.4\ m/s$

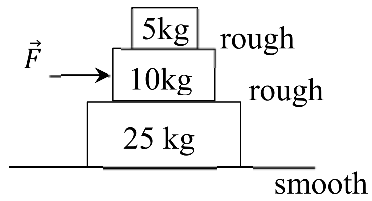
SP4. A small block with mass 0.4 kg is moving in the xy-plane. The net force on the block is described by the potential-energy function U(x,y) = 6x^2-4y^3 where U is measured in J and x and y are measured in m. **What is the acceleration of the block when it is at the point x = 1 m, y = 1 m in unit vector notation?**

$\vec{F} = -\frac{\partial U}{\partial x}\hat{\imath} - \frac{\partial U}{\partial y}\hat{\jmath}$

$m\vec{a} = -12\ x\ \hat{\imath} + 12y^2\hat{\jmath}$ $\quad$ $0.4\vec{a} = -12\hat{\imath} + 12\hat{\jmath} \Rightarrow \vec{a} = -30\hat{\imath} + 30\hat{\jmath}\ m/s^2$

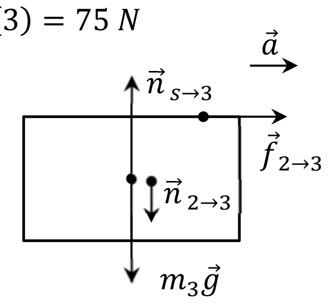
Answer: $\vec{a} = -30\hat{\imath} + 30\ \hat{\jmath}\ m/s^2$

SP5. A horizontal applied force of magnitude F = 120 N is applied to a system of blocks which move together to the right on a frictionless horizontal table, as shown in the figure. **If the three blocks do not slip with respect to each other**, and coefficients of friction between all blocks are the same (μ_k = 0.4 and μ_s = 0.7), **find the magnitude of the friction force between the lower two blocks**.



$f_{2\to3} = m_3 a$

$f_{2\to3} = 25(3) = 75\ N$



$*\ F = m_{ToT}\ a$

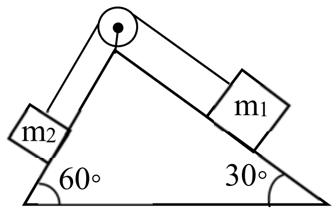
$120 = 40\ a$

$\Rightarrow a = 3\ m/s^2$

Answer: $75\ N$

Part III: Long Problems (3 points each)

LP1. Two blocks of mass $m_1 = 100$ kg and $m_2 = 80$ kg connected by a light cord passing over a massless frictionless pulley rest on frictionless planes, as shown in the figure.



a. **(0.5 point) Which way will the system move when the blocks are released from rest? Justify your answer. (No points without justification!)**

$m_2\, g \sin 60° = 80\,(10) \sin 60° = 400\,\sqrt{3} N$

$m_1\, g \sin 30° = 100\,(10) \sin 30° = 500\; N$

$m_2\, g \sin 60° > m_1\, g \sin 30°$

$\Longrightarrow$ system moves to left.

Answer: Left

b. (1.5 points) What is the magnitude of the acceleration of the blocks?

$m_2\, g \sin 60° - T = m_2 a$

$T - m_1\, g \sin 30° = m_1 a$

$(m_2\, g \sin 60° - m_1\, g \sin 30°) = (m_1 + m_2)a$

$400\sqrt{3} - 500 = 180\; a$

$\Longrightarrow a = \frac{20\sqrt{3}-25}{9}\; m/s^2 \approx 1.1\; m/s^2$

Answer: 1.1 m/s^2

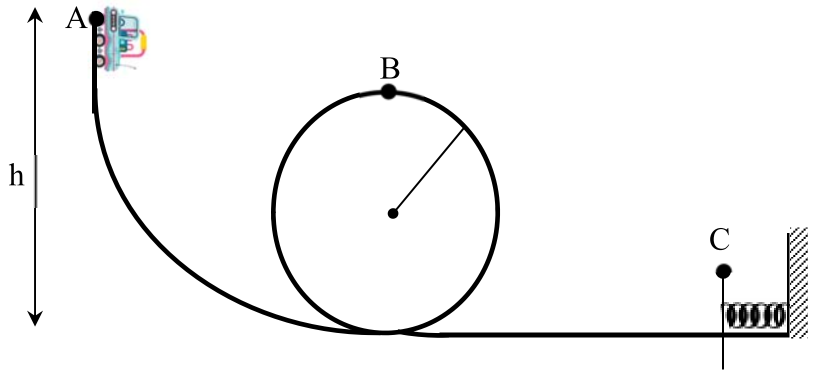
c. (1 point) What is the tension in the rope?

$T - m_1 g \sin 30° = m_1 a$

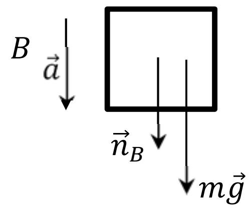
$T = m_1(g \sin 30° + a) = 100\,(10 \sin 30° + 1.1) \approx 610\; N$

Answer: 610 N

LP2. A car of mass m in an amusement park ride rolls without friction around a track, as shown in the figure. The car starts from rest at a point A at a height h above the bottom of the circular loop of radius R. It completes a loop then compresses a spring at point C a distance of x = 1.2 m before stopping momentarily.



a) (2 points) Find the <u>minimum height</u> (h_{min}) in terms of R such that the car completes the vertical loop <u>without falling off the top of the loop (point B).</u>



$E_A = E_B$

$mgh = \frac{1}{2} mv_B^2 + mg\,(2R)$ $\qquad n_B + mg = mv_B^2/R$

$mgh_{min} = \frac{1}{2} m\underbrace{v_{B,min}^2}_{gR} + 2mg\,R$ $\qquad n_B = 0 \Longrightarrow\ v_{B,min}^2 = Rg$

$\Longrightarrow h_{min} = \frac{R}{2} + 2R = {}^5\!/_2\, R$

Answer: $h_{min} = {}^5\!/_2\, R$

b) <u>(1 point)Suppose now h = 3R, R = 15 m, and m = 100 kg. Find the value of the spring constant k.</u>

$E_A = E_C$

$mgh = \frac{1}{2}\,kx^2 \ \Longrightarrow \qquad k = \frac{2mgh}{x^2} = \frac{2(100)(10)(3)(15)}{(1.2)^2} = 62500\ N/m$

Answer: $62500\ N/m$