Name:	Signature:
Surname:	Number:

Fall 2018

KOÇ UNIVERSITY

College of Sciences

PHYS 101 General Physics 1

Fall Semester 2018

Midterm II Exam

November 22, 2018 Thursday, 19:00-20:40

Solutions

Please read.

- Count to make sure that there are 5 pages in this question booklet
- Check your **name, number, on front page, and student ID on each page.**.
- This examination is conducted with closed books and notes.
- Put all your personal belongings underneath your seat and make sure that pages of books or notebooks are not open.
- Absolutely no talking or exchanging anything (like rulers, erasers) during the exam.
- You must show all your work to get credit; you will not be given any points unless you show the details of your work (this applies even if your final answer is correct).
- Write neatly and clearly; unreadable answers will not be given any credit.
- If you need more writing space, use the backs of the question pages and put down the appropriate pointer marks.
- Make sure that you include units in your results.
- Make sure that you label the axis and have units in your plots.
- You are not allowed to use calculators during this exam.
- Turn off your mobile phones, and put away.
- You are not allowed to leave the class during the first 15 minutes, and last 15 minutes.
- Write your final answers into the boxes. No points will be given to unjustified answers. Incomplete calculations will not be graded.

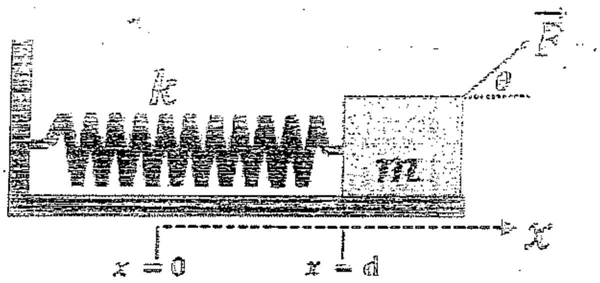
P101_Index:

1	2	3	4	Total

F18_MT2

[redacted]	[redacted]
Student ID Number [redacted]	Signature:

Q1-(25 pts) A block of mass m is on a horizontal surface and is attached to a spring whose other end is fixed. The spring constant is k. The coefficient of kinetic friction between the block and the horizontal surface is μ. A force $\vec{F}$ acts on the block always making an angle θ with the horizontal, as shown in the figure. The magnitude of the force is adjusted so that the block moves with constant speed v on the surface from x=d to the equilibrium position of the spring (x=0).



a) (5 pts) Find the work done by the gravitational force.

$W_G = \vec{F}_G \cdot \vec{d} = F_G d \cos\theta$

$\vec{F}_G \perp \vec{d}$ thus $\cos 90 = 0$

Answer: 0 Joule

b) (5 pts) Find the work done by the spring force.

$W_{el} = -\Delta U = \int_d^0 -k\,x\,dx = -\frac{kx^2}{2}\Big|_d^0$

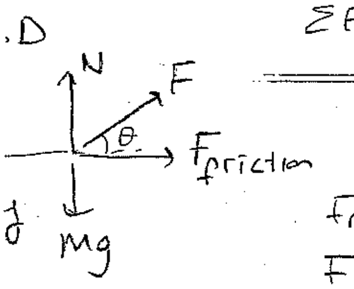
$= -\left[0 - \frac{kd^2}{2}\right] = \frac{kd^2}{2}$

Answer: $\frac{1}{2}kd^2$

c) (10 pts) What is the power due to $\vec{F}$ as a function of the position x?

Answer: $(kx - mg\mu)(v\cos\theta)$ / ~~$\cos\theta - \mu\sin\theta$~~

$\Sigma F = 0$ ∴ speed is constant



~~$F_{fric} = N.\mu$~~

$N + F\sin\theta = mg$

$F_{fric} = (mg - F\sin\theta)\mu$

$P = \vec{F} \cdot \vec{V}$

$= FV\cos\theta$

$f_{fric} + F\cos\theta = k.x$

$F = (kx - mg\mu)/(\cos\theta - \mu\sin\theta)$

d) (5 pts) What is the work done by the net force?

$W_{net} = \Delta KE \Rightarrow V$ constant

$\Delta KE = 0$ Joule

or

$W_{net} = \Sigma \vec{F} \cdot \vec{d}$ since V is constant

$\Sigma F = 0 \Rightarrow W_{net} = 0$ Joule

Answer: 0 Joule

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Q2-(25 pts) A small object with mass m moves along the **+x**-axis. The only force on the object is a conservative force that has the potential-energy function $U(x) = Ax^2 + Bx^3$, where $A<0$ and $B>0$ are constants in time, and x is the position in meters. The object is released from rest at the origin.

a) (7 pts) Find its speed as a function of x.

$\vec{F} = -\frac{\partial U}{\partial x}$;

$\vec{a} = \vec{F}/m$

$d\vec{V} = \vec{a}\, dt = \vec{a} \frac{dt}{dx} dx \Rightarrow \int dV \cdot V = \vec{a} \cdot dx$

$\sqrt{\frac{2(Ax^2 + Bx^3)}{m}}$

b) (7 pts) Find its acceleration as a function of x.

$\vec{a} = \vec{F}/m$

$\frac{-2Ax - 3Bx^2}{m}$

c) (11 pts) What is the maximum value of x reached by the object during its motion?

$x = -A/B.$

Solution continues on the back side of the page Yes □ No □

Exam Room:	P101_Index:
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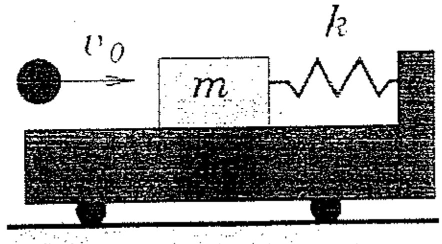
Q3-(25 pts) A block of mass m is connected to a platform of mass $2m$ with a spring of spring constant k. A bullet of mass m hits the block with velocity $v_0\hat{\imath}$, and gets stuck in it at $t = 0$. The spring goes back to its equilibrium length for the first time at $t = T$. There is no friction on any surface, and the block and the platform are initially at rest.



a) (5 pts) What is the velocity of the block immediately after the bullet is stuck?

$m v_0 = 2m v_b$

$v_b = \frac{v_0}{2}$

b) (8 pts) What is the maximum compression of the spring?

$\frac{1}{2} 2m \left(\frac{v_0}{2}\right)^2 = \frac{1}{2} 4m v_f^2 + \frac{1}{2} k x^2$

$m v_0 = 4m v_f \Rightarrow v_f = \frac{v_0}{4}$

$\Rightarrow \frac{1}{2} k x^2 = \frac{1}{8} m v_0^2 \Rightarrow x = \sqrt{\frac{m}{k}} \frac{v_0}{2}$

$\sqrt{\frac{m}{k}} \frac{v_0}{2}$

c) (7 pts) What are the velocities of the block and the platform at $t = T$?

$2m \frac{v_0}{2} = 2m v_b + 2m v_p$

$\frac{1}{2} 2m \left(\frac{v_0}{2}\right)^2 = \frac{1}{2} 2m v_b^2 + \frac{1}{2} 2m v_p^2$

$\left(\frac{v_0}{2}\right)^2 = v_b^2 + v_p^2 + 2 v_b v_p$

$\left(\frac{v_0}{2}\right)^2 = v_b^2 + v_p^2$

$\Rightarrow 2 v_b v_p = 0 \Rightarrow v_b = 0 \quad v_p = \frac{v_0}{2}$ [the other option is not physical]

$v_{block} = 0$
$v_{platform} = v_0/2$

d) (5 pts) What is the displacement of the platform from $t = 0$ to $t = T$? *Hint: Think about the center of mass motion of the whole system.*

$4m v_{cm} = m v_0 \Rightarrow v_{cm} = \frac{v_0}{4}$

At spring equilibrium the displacement of the platform is equal to CM displacement

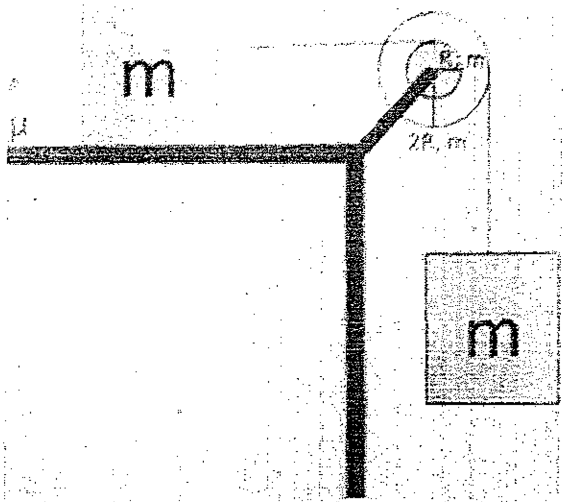
$\Delta x = v_{cm} T = \frac{v_0 T}{4}$

$\frac{v_0 T}{4}$

Solution continues on the back side of the page Yes ☐ No ☐

Student ID Number:	Signature:

Q4-(25 pts) Two uniform metal discs, one with radius R and mass m, the other with radius 2R and mass m are welded together and mounted on a frictionless axis through their common center to form a pulley. Block A and block B, both has mass m, are connected to the pulley with the massless ropes as shown in the figure. The rope does not slip over the discs. The coefficient of kinetic friction between the block A and the horizontal surface is μ. The system is released from rest and block B descends.



a) Calculate the total moment of inertia of the pulley with respect to the rotation axis.
(for disc $I_{cm} = \frac{1}{2}MR^2$)

$$I_{Total} = I_{small} + I_{big} \quad (2\ pts)$$
$$= \frac{1}{2} m R^2 + \frac{1}{2} m (2R)^2 = \frac{5}{2} m R^2 \quad (3\ pts)$$

Answer: $\frac{5}{2} m R^2$

b) Show the direction of angular velocity of the pulley. What is the magnitude of angular velocity in terms of velocity of block B? What is the ratio of velocity of block B and block A?

2 pts — right hand rule: $\vec{\omega}$ ⊗

$\omega = \frac{v_B}{2R}$ $\quad \frac{v_B}{v_A} = \frac{\omega \cdot 2R}{\omega \cdot R} = 2$

3 pts

c) Calculate the speed of block B when it moves down by a distance d.

(2 pts) → $K_1 + U_1 + W_{other} = K_2 + U_2$

(5 pts) → $0 + mgd - \mu mg\, d/2 = \frac{1}{2} m v_B^2 + \frac{1}{2} m v_A^2 + \frac{1}{2} I \omega^2 + 0$

$mgd(1 - \mu/2) = \frac{1}{2} m v_B^2 + \frac{1}{2} m \left(\frac{v_B}{2}\right)^2 + \frac{1}{2}\left(\frac{5}{2} m R^2\right)\left(\frac{v_B}{2R}\right)^2$

$= \frac{15}{16} m v_B^2 \Rightarrow v_B = \sqrt{\frac{16 g d}{15}\left(1 - \frac{\mu}{2}\right)}$

(calc. 5 pts)

for friction, if take d (instead of d/2) take out 2 pts ... [illegible]

Answer: $v_B = \left[\frac{16 g d}{15}\left(1 - \mu/2\right)\right]^{1/2}$

Solution continues on the back side of the page: Yes ☐ No ☐