# Midterm 2 Winter 2019, questions and answers

Dynamics (Concordia University)

CONCORDIA UNIVERSITY
FACULTY OF ENGINEERING AND COMPUTER SCIENCE

*Department of Mechanical, Industrial and Aerospace Engineering*

# MIDTERM 2

ENGR 243: Dynamics: Winter 2019

Maximum Marks = 20

Version 1

Instructors: Dr. Hany Gomaa — Section: T

Date: 28th March 2019 — Time: 75 minutes

NAME: _____
(Please Print) SURNAME FIRST NAME

STUDENT ID: _____ SECTION: _____

SIGNATURE: _____

INSTRUCTOR: _____

Name and student I/D must be written in INK.

All work and solution steps must be illustrated in order to gain full marks assigned to the question.

INDIVIDUAL WORK - Closed Book Test

Material allowed: Approved calculator only

Answer the questions in the space provided.

Return the paper at the end of the scheduled time.

| Q1 (1) | Q2 (4) | Q3 (4) | Q4 (5) | Q5 (6) | Total (20) |
|---|---|---|---|---|---|
| | | | | | |

**Question No. 1** [1 Mark]
**Encircle** the correct answer for the following multiple-choice question (***only one***).

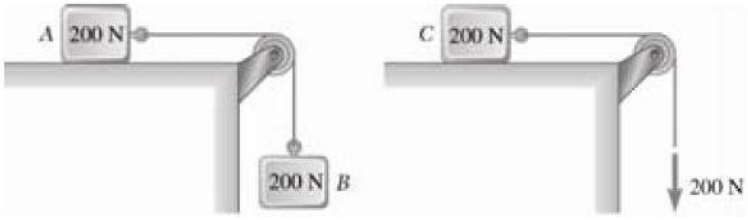
The two systems shown start from rest. On the left, two 200 N weights are connected by an inextensible cord, and on the right, a constant 200 N force pulls on the cord. Neglecting all frictional forces, which of the following statements is true?

(*a*) Blocks *A* and *C* will have the same acceleration

(*b*) Block *C* will have a larger acceleration than block *A*

(*c*) Block *A* will have a larger acceleration than block *C*

(*d*) Block *A* will not move (*e*) None of the above




Answer: (*b*) If you draw a FBD of *B*, you will see that since it is accelerating downward, the tension in the cable will be less than 200 N, so the acceleration of *A* will be less than the acceleration of *C*. Also, the system on the left has more inertia, so it is harder to accelerate than the system on the right.

**Question No. 2** [4 Marks]

The radius of the pulley is $R$ = 100 mm and its moment of inertia is $I$ = 0.1 kg-m$^2$. The mass $m$ = 5 kg. The spring constant is $k$ = 135 N/m. The system is released from rest with the spring unstretched. Determine how fast the mass is moving when it has fallen 0.5 m. All surfaces are smooth.


Question 2 solution

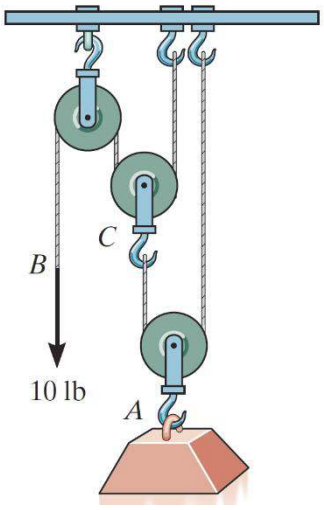
$$T_1 = 0,\ V_1 = 0,\ T_2 = \frac{1}{2}(5\text{ kg})v^2 + \frac{1}{2}(0.1\text{ kg-m}^2)\left(\frac{v}{0.1\text{ m}}\right)^2$$

$$V_2 = -(5\text{ kg})(9.81\text{ m/s}^2)(0.5\text{ m}) + \frac{1}{2}(135\text{ N/m})(0.5\text{ m})^2$$

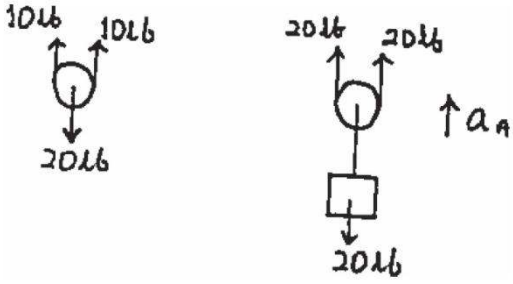
$$T_1 + V_1 = T_2 + V_2 \Rightarrow \boxed{v = 1.01\text{ m/s}}$$

**Question No. 3** [4 Marks]

Determine the time needed to pull the cord at *B* down 4 ft starting from rest when a force of 10 lb is applied to the cord. Block *A* weighs 20 lb. Neglect the mass of the pulleys and cords.




Question 3 solution




$$+\uparrow \Sigma F_y = ma_y; \qquad 40 - 20 = \frac{20}{32.2} a_A \qquad \textbf{Ans.}$$

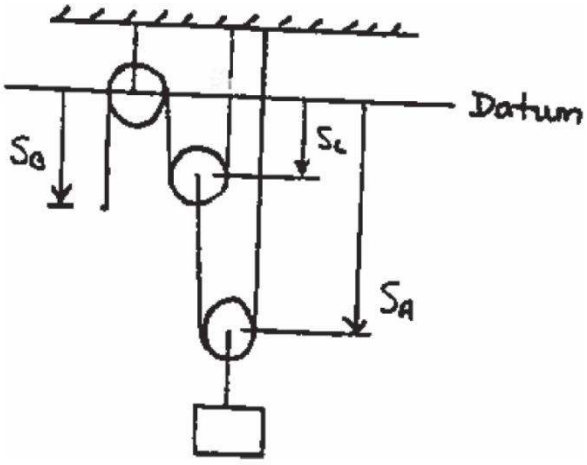
$$a_A = 32.2 \text{ ft/s}^2$$

$$s_B + 2s_C = l; \qquad a_B = -2a_C$$

$$2s_A - s_C = l'; \qquad 2a_A = a_C$$

$$a_B = -4a_A$$

$$a_B = 128.8 \text{ ft/s}^2$$




$$(+\downarrow) \quad s = s_0 + v_0 t + \frac{1}{2} a_c t^2$$

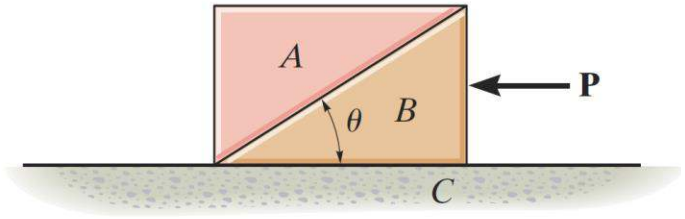
$$4 = 0 + 0 + \frac{1}{2}(128.8)\, t^2$$

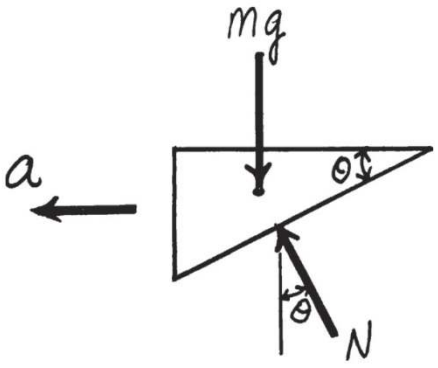
$$t = 0.249 \text{ s} \qquad \textbf{Ans.}$$

**Question No. 4** [5 Marks]

Blocks *A* and *B* each have a mass *m*. Determine the largest horizontal force ***P*** which can be applied to *B* so that *A* will not move relative to *B*. All surfaces are smooth.

Question 4 solution




Require

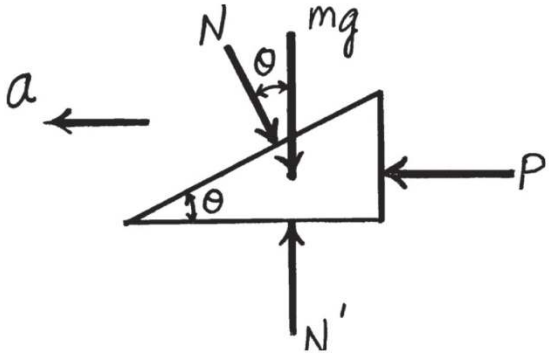
$a_A = a_B = a$

Block *A*:

$+\uparrow \Sigma F_y = 0; \qquad N\cos\theta - mg = 0$

$\overset{+}{\leftarrow} \Sigma F_x = ma_x; \qquad N\sin\theta = ma$

$a = g\tan\theta$




Block *B*:

$\overset{+}{\leftarrow} \Sigma F_x = ma_x; \qquad P - N\sin\theta = ma$

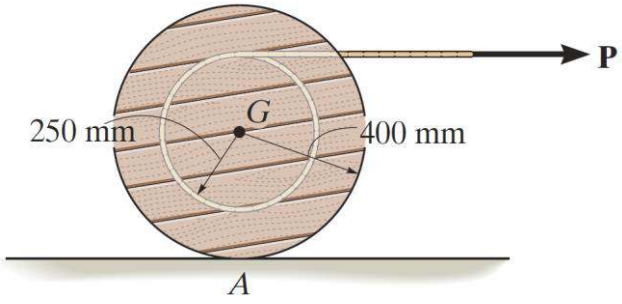
$P - mg\tan\theta = mg\tan\theta$

$P = 2mg\tan\theta$ **Ans.**

**Question No. 5** [6 Marks]

The spool has a mass of 100 kg and a radius of gyration of $k_G = 0.3$ m. If the coefficients of static and kinetic friction at $A$ are $\mu_s = 0.2$ and $\mu_k = 0.15$, respectively, determine the angular acceleration of the spool if P = 50 N.

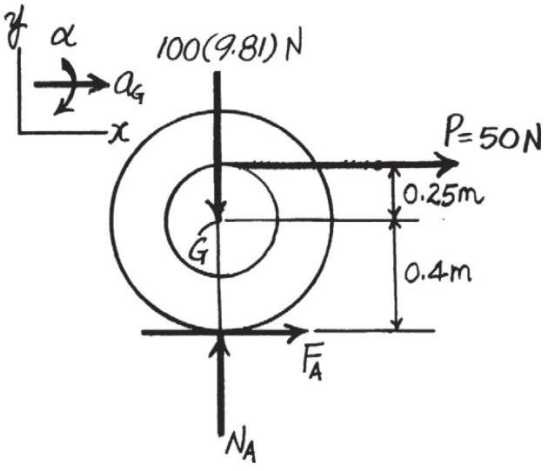
Question 5 solution




$\stackrel{+}{\rightarrow} \Sigma F_x = m(a_G)_x;$ $\quad 50 + F_A = 100a_G$

$+\uparrow \Sigma F_y = m(a_G)_y;$ $\quad N_A - 100(9.81) = 0$

$\circlearrowleft + \Sigma M_G = I_G\alpha;$ $\quad 50(0.25) - F_A(0.4) = [100(0.3)^2]\alpha$




Assume no slipping: $a_G = 0.4\alpha$

$\alpha = 1.30 \text{ rad/s}^2$ **Ans.**

$a_G = 0.520 \text{ m/s}^2$ $\quad N_A = 981 \text{ N}$ $\quad F_A = 2.00 \text{ N}$

Since $(F_A)_{\max} = 0.2(981) = 196.2 \text{ N} > 2.00 \text{ N}$ **OK**

Continue Question 5 solution

## Additional Draft Paper

## Additional Draft Paper

# Formula sheet

$$v = v_0 + a(t - t_0)$$

$$v^2 = {v_0}^2 + 2a(x - x_0)$$

$$x = x_0 + v_0(t - t_0) + \frac{a}{2}(t - t_0)^2$$

$$\vec{v} = v\vec{e_t}$$

$$\vec{a} = a_t\vec{e}_t + \frac{v^2}{\rho}\vec{e}_n$$

$$\vec{r} = r\vec{e_r}$$

$$\vec{v} = \dot{r}\,\vec{e_r} + r\dot{\theta}\vec{e_\theta}$$

$$\vec{a} = \left[\ddot{r} - r\dot{\theta}^2\right]\vec{e_r} + \left[2\dot{r}\dot{\theta} + r\ddot{\theta}\right]\vec{e_\theta}$$

$$\vec{v_B} = \vec{v_A} + \vec{v_{B/A}}$$

$$x = x_0 + v_{x0}(t - t_0)$$

$$y = y_0 + v_{y0}(t - t_0) - 4.905(t - t_0)^2$$

$$v_y = v_{y0} - 9.81(t - t_0)$$

$${v_y}^2 = {v_{y0}}^2 - 19.62(y - y_0)$$

$$\vec{v} = \vec{\omega} \times \vec{r}$$

$$\vec{a} = \vec{\alpha} \times \vec{r} + \vec{\omega} \times (\vec{\omega} \times \vec{r})$$

$$\vec{\mathrm{v}}_B = \vec{\mathrm{v}}_A + \vec{\Omega} \times \vec{r}_{B/A} + \left(\vec{\mathrm{v}}_{B/A}\right)_{xyz}$$

$$\vec{a}_B = \vec{a}_A + \dot{\vec{\Omega}} \times \vec{r}_{B/A} + \vec{\Omega} \times \left(\vec{\Omega} \times \vec{r}_{B/A}\right) + 2\vec{\Omega} \times \left(\vec{\mathrm{v}}_{B/A}\right)_{xyz} + \left(\vec{a}_{B/A}\right)_{xyz}$$

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

$$\sum \vec{M} = I\vec{\alpha}$$

$$\vec{H_0} = \vec{r} \times m\vec{v}$$

$$U_{1\to2} = \int \vec{F} \cdot d\vec{r}$$

$$U_{1\to2}^{tot} = \Delta T \ , \ T = \tfrac{1}{2}mv^2$$

$$P = \frac{dU}{dt} = \vec{F} \cdot \vec{v}$$

$$\frac{1}{2}m{v^2}_1 + mgy_1 + \frac{1}{2}k{x^2}_1 + U_{1\to2}^{nc} = \frac{1}{2}m{v^2}_2 + mgy_2 + \frac{1}{2}k{x^2}_2$$

$$m\vec{v_1} + \int \vec{F}dt = m\vec{v_2}$$

$$e = \frac{{v_2}` - {v_1}`}{v_1 - v_2}$$

$$U_{1\to2} = \int \vec{M} \cdot d\vec{\theta}$$

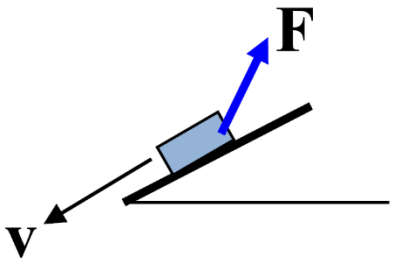
$$T = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

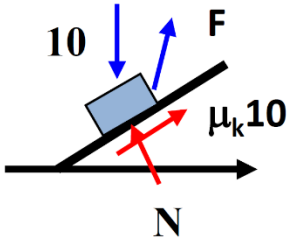
$$I\vec{\omega_1} + \int \vec{M}dt = I\vec{\omega_2}$$

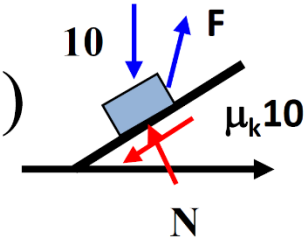
$$I_0 = \bar{I} + mr^2$$

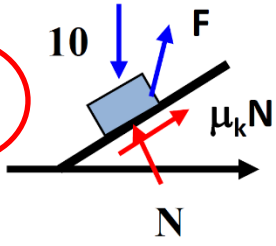
**Question No. 1** [1 Mark]
**Encircle** the correct answer for the following multiple-choice question (***only one***).

A 10 lb block is initially moving down a ramp with a velocity of ***v***. The force ***F*** is applied to bring the block to rest. Select the correct FBD.




A)



B)



C)


**Question No. 1** [1 Mark]
**Encircle** the correct answer for the following multiple-choice question (***only one***).

The tangential acceleration of an object

A) represents the rate of change of the velocity vector's direction.

B) represents the rate of change in the magnitude of the velocity.

C) is a function of the radius of curvature.

D) Both B and C.

**Question No. 1** [1 Mark]
**Encircle** the correct answer for the following multiple-choice question (***only one***).

The mass moment of inertia of any body about its center of mass is always _____.

A) maximum

B) minimum

C) zero

D) None of the above

**Question No. 1** [1 Mark]
**Encircle** the correct answer for the following multiple-choice question (***only one***).

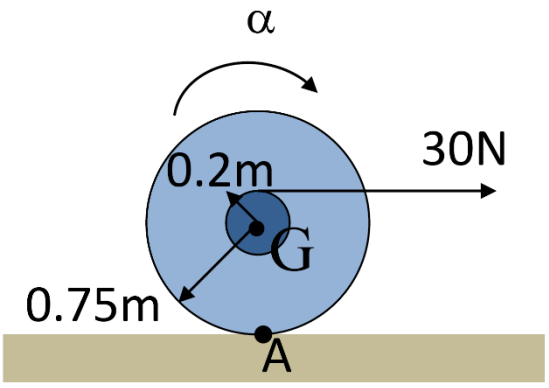
Select the equation that best represents the "no-slip" assumption.

A) $F_f = \mu_s N$

B) $F_f = \mu_k N$

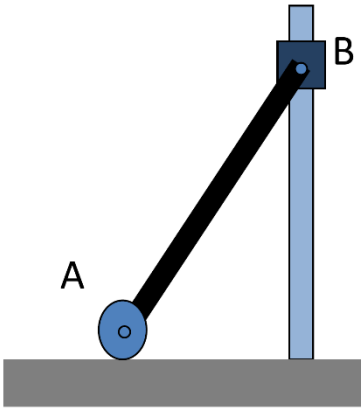
C) $a_G = \alpha r$

D) None of the above

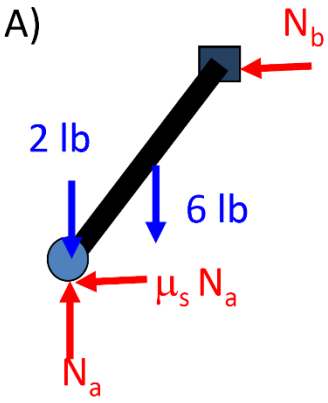


**Question No. 1** [1 Mark]
**Encircle** the correct answer for the following multiple-choice question (***only one***).

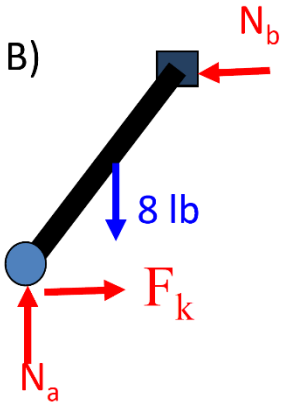
A 2 lb disk is attached to a uniform 6 lb rod AB with a frictionless collar at B. If the disk rolls with slipping, select the correct FBD.




A)




B)




C)