Physics 5A - Winter 2021 Midterm 3

ZOE GLEASON

TOTAL POINTS

100 / 100

QUESTION 1

1 1 **4 / 4**

✓ **- 0 pts** Correct

- 4 pts Incorrect

QUESTION 2

2 2 **4 / 4**

✓ **- 0 pts** Correct

- 4 pts Incorrect

QUESTION 3

3 3 **4 / 4**

✓ **- 0 pts** Correct

- 4 pts Incorrect

QUESTION 4

4 4 **4 / 4**

✓ **- 0 pts** Correct

- 4 pts Incorrect

QUESTION 5

5 5 **4 / 4**

✓ **- 0 pts** Correct

- 4 pts Incorrect

QUESTION 6

6 6 **40 / 40**

✓ **+ 40 pts** Correct $$a = \frac{mg(\sin\theta - \mu_k (1+\cos\theta))}{2m + M_{p}/2}$$

+ 10 pts Partial Credit: Block 1 $$ ma = T_1 - \mu_k mg $$

+ 10 pts Partial Credit: Block 2 $$ ma = mg\sin\theta - \mu_kmg \cos\theta -T_2$$

+ 10 pts Partial Credit: Pulley $$T_2R - T_1R = I_{pulley}\alpha$$

+ 5 pts Partial Credit: No Slipping $$\alpha = a/R$$

+ 0 pts No points

QUESTION 7

7 **40 / 40**

✓ **- 0 pts** Correct

- 10 pts Incorrect final answer

- 5 pts Incorrect unit for final answer

- 10 pts Incorrect understanding for balancing of torque

- 10 pts Incorrect equation established for balancing of torque

- 5 pts Wrong concept of force

Midterm 3

Physics 5A, Winter 2021

Full Name (Printed) Zoe Gleason

Full Name (Signature)

Student ID Number 405308281

There is only one correct answer for each multiple-choice question. Clearly circle your multiple choice answers.

On free-answer questions, it is not sufficient to just present the final answer on any given problem. **You need to show all of your work** in your solution to justify your steps so that another person can understand how you arrived at the final answer. **All work must be your own and do not communicate with anyone about the exam.** Be prepared to defend anything you write down in a potential follow-up oral examination.

Your submitted exam on Gradescope must contain the same number of pages as the original exam packet and your solutions must be clearly written in the spaces below each question with your final answer clearly boxed or circled. (You may want to work on the problems on scratch paper, and when you are happy with your solution, write down your final solution in the space provided on the exam packet. But, do not turn in scratch paper on Gradescope – I will only grade what is written in the proper sections on the exam packet.)

Have fun! Good luck!

Multiple-choice Section – Each question only has one correct answer, *unless* otherwise stated in the problem.

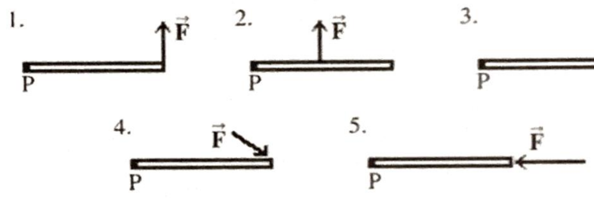
1. Two forces produce equal torques on a door about the door hinge. The first force is applied at the midpoint of the door; the second force is applied at the doorknob. Both forces are applied perpendicular to the door. Which force has a smaller magnitude?

   A) the first force (at the midpoint)
   [✓ B) the second force (at the doorknob)]
   C) The two forces are equal.

B

2. As shown in the figure, a given force is applied to a rod in several different ways. In which case is the magnitude of the torque about the pivot P due to this force the smallest?

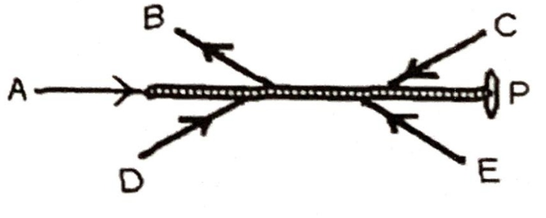
   A) 1
   B) 2
   C) 3
   D) 4
   [✓ E) 5]



E

3. Five forces act on a rod that is free to pivot at point P, as shown in the figure. Which of these forces is producing a counter-clockwise torque about point P? (There could be more than one correct choice.)

   A) force A
   B) force B
   [✓ C) force C]
   D) force D
   E) force E



C

4. If both the net force and net torque on an object is zero, then the object must be at rest.

A) True
[✓ B) False]

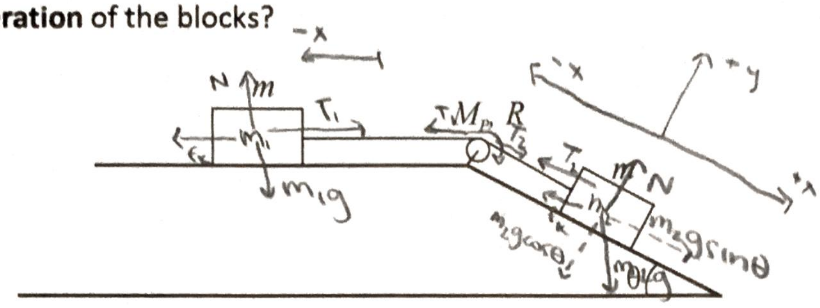
B

5. In order for an object at rest to remain at rest, there can be no net torque or net force on the object.

[✓ A) True]
B) False

A

6. Two boxes have identical masses m and are attached to each other by a massive cylindrical pulley. The pulley has a moment of inertia $\boxed{I = \frac{1}{2} M_P R^2,}$ where M_P is the mass of the pulley and R is the radius of the pulley. The box on the incline slides down the hill, which is at an angle θ above horizontal, and both blocks experience a sliding frictional force with friction coefficient μ_k. You can assume the string is massless and does not slip across the pulley. What is the **acceleration** of the blocks?



CCW → -

CW → +

[Hint: Your answer should be a symbolic solution in terms of m, M_P, R, g, θ.]
[Hint: Show all of your work, solve the problem from scratch, and clearly box or circle your final answer.]

$\Sigma F = ma \qquad \Sigma \tau = I\alpha$

on m_1: $\Sigma F_{on\, m_1} = T_1 - f_k = m_1 a \rightarrow T_1 = f_k + m_1 a$

on T_1 $f_k = \mu_k (m_1 g)$ $\quad T_1 = \mu_k (m_1 g) + m_1 a$

on m_2: $\Sigma F_{on\, m_2} = m_2 g \sin\theta - T_2 - f_k = m_2 a$

$T_2 = m_2 g \sin\theta - \mu_k (m_2 g \cos\theta) - m_2 a$

on T_2 $f_k = \mu_k (m_2 g \cos\theta)$ $\quad T_2 = m_2 g \sin\theta - \mu_k (m_2 g \cos\theta) - m_2 a$

$\tau_{cm} = F r_{cm} \sin\theta \qquad \sin(90) = 1 \qquad a_{tan} = r\alpha$

$\alpha = a/R$

$\Sigma \tau_{cm} = T_1 R - T_2 R = -I_{cm}\alpha$

$+ \circlearrowleft \qquad \circlearrowright - \qquad \circlearrowright -$

$T_1 R - T_2 R = -(1/2\, M_P R^2)(\frac{a}{R})$

→

Extra space for problem 6.

Please include this page in your solutions. Even if you do not use this extra space, insert the blank page into your solutions to ensure you are uploading the same number of pages in the same order as the original exam packet.

$$(\mu_K(m_1 g) + m_1 a)R - (m_2 g\sin\theta - \mu_K(m_2 g\cos\theta - m_2 a)R = -(\tfrac{1}{2}M_p R^2)(\tfrac{a}{R})$$

$\downarrow$

$$\mu_K m_1 g + m_1 a - m_2 g\sin\theta + \mu_K(m_2 g\cos\theta) + m_2 a = -\tfrac{1}{2}M_p a$$

$\downarrow$

$$m_1 a + m_2 a + \tfrac{1}{2}M_p a = m_2 g\sin\theta - \mu_K m_1 g - \mu_K(m_2 g\cos\theta)$$

$$a(m_1 + m_2 + \tfrac{1}{2}M_p)$$

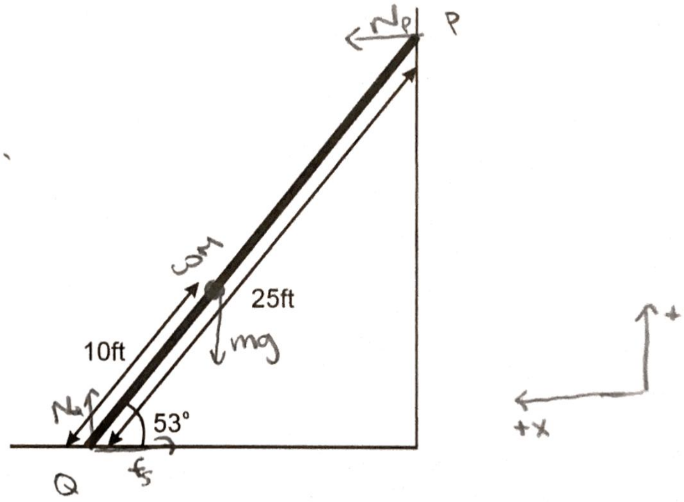
$\downarrow$

$$\boxed{a = \frac{m_2 g\sin\theta - \mu_K m_1 g - \mu_K(m_2 g\cos\theta)}{m_1 + m_2 + \tfrac{1}{2}M_p}}$$

7. A ladder is propped up on a rough floor against a frictionless wall. The center of mass of the ladder is 10 ft from the bottom of the ladder, whose overall length is 25 ft, as shown in the figure. The ladder weighs 80 lbs. The coefficients of friction between the ladder and the floor are $\mu_s = 0.5$ and $\mu_k = 0.3$. (The wall is frictionless; i.e., $\mu_{wall} = 0$)

What is the magnitude and direction of the force that the vertical wall pushes against the ladder? Give your answer in pounds.

(Hint: Pounds are a unit of force.)



$25\,ft \cdot 0.305\,m/ft = 7.625\,m$

$10\,ft \cdot 0.305\,m/ft = 3.05\,m$

$80\,lb \cdot 0.4536\,kg/1\,lb = 36.288\,kg$

$\Sigma\tau = 0$

$\Sigma\tau_Q = 0 = \tau_{N_p} + \tau_g + \overset{0}{\cancel{\tau_{N_Q}}} + \overset{0}{\cancel{\tau_{f}}}$

$\tau = Fr\sin\theta = F_\perp r_A = F r_{\perp A}$

$\tau_{N_p} - \tau_Q = 0$

$+\circlearrowleft \qquad \circlearrowright -$

$N_p r_{Q\perp} - mg r_{Q\perp}$

$N_p(L\sin\theta) - mg(3.05\cos\theta) = 0$

$$N_p = \frac{36.288 \cdot 9.8\,(3.05\cos 53^\circ)}{7.625\sin 53}$$

$N_p = 107.19N \cdot 1lb/4.45N = \boxed{24.1\text{lbs of force to the left}}$

Extra space for problem 7.

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