Phys 231 Exam 3
March 30, 2018

NAME: Solutions

Student I.D. No._____.

Keep in mind that I must be able to follow your work in order to give you credit. This is especially true when awarding partial credit. A wrong answer with the right methods gets partial credit. If I cannot figure out the methods then no credit even if the answer is correct.

Answers must be justified. An answer by itself receives no credit.

All Units All the Time!

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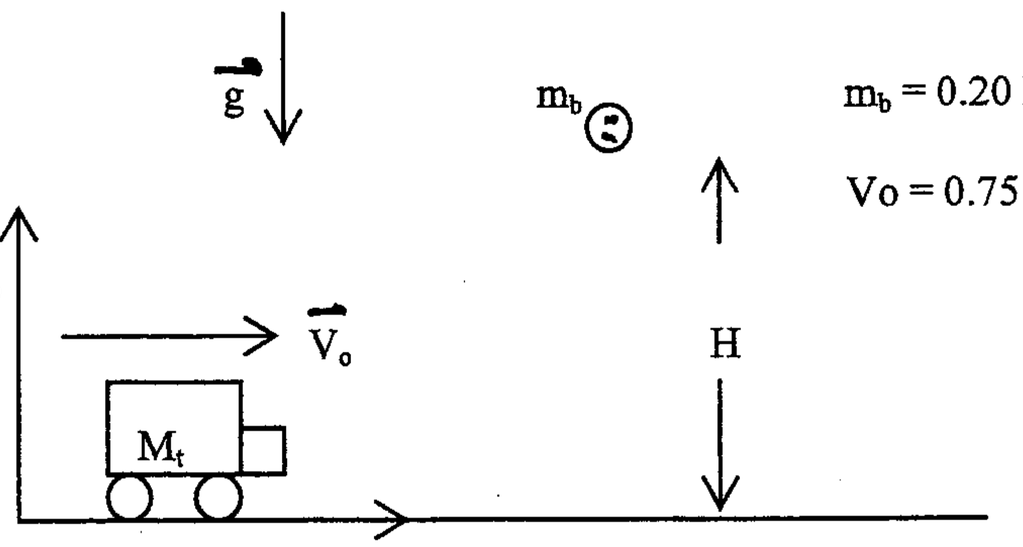
1) (20 pts) The picture below shows a toy truck moving with constant initial velocity along a rigid surface with no friction. A ball is dropped (zero initial velocity) from a height H and lands in the truck. The ball bounces around a bit and stays in the truck. Both the truck and the ball may be treated as point-like objects.

$V_y = -\sqrt{2gH}$

$= -\sqrt{(2)(9.8\frac{m}{s^2})(0.75 m}$

$= -3.8 m/s$



$m_b = 0.20$ kg $M_t = 0.60$ kg

$Vo = 0.75$ m/s $H = 0.75$ m

a) Use the co-ordinate system drawn on the diagram. What is the center of mass velocity (vector) of the system (truck plus ball) just before the collision of the ball and truck?

$$\vec{V}_{cm} = \frac{M_t \vec{V}_0 + m_b \vec{V}_b}{M_t + m_b}$$

$$= \frac{(0.75\frac{m}{s})(0.60 kg)\hat{i} + (3.8\frac{m}{s})(0.20 kg)(-\hat{j})}{0.80 kg}$$

$= (0.56\hat{i} - 0.95\hat{j})$ m/s

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b) What is the center of mass velocity (vector) of the system (truck plus ball) after the ball is in the truck and is at rest with respect to the truck?

$$\vec{V}_{cm} = 0.56\hat{i}\ \frac{m}{s}$$

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c) What is the velocity (vector) of the truck – ball system after the ball lands in the truck?

$$V = 0.56 \frac{m}{s} \hat{i}$$

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d) Remember that momentum is a vector. You must provide justification to your answers to the following questions. A correct answer without the proper justification receives no credit

i) Is the X-component of momentum of the system (ball plus truck) conserved by the collision of the truck and ball?

Yes - no external forces act along the X-axis

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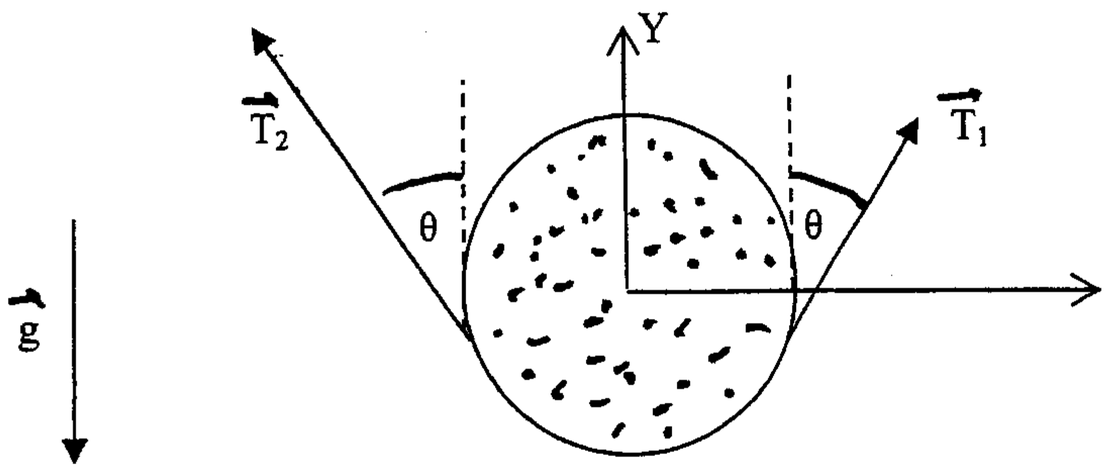
ii) Is the Y-component of momentum of the system conserved by the collision of the truck and ball?

No. $N - mg \neq 0$ during the collision. There is a net y-component of external force acting during the collision

2) (15 pts) The picture below shows a pulley with a belt wrapped around it with the tensions T in the belt specified. Not drawn is the stationary bearing at the center of the pulley about which the pulley rotates.



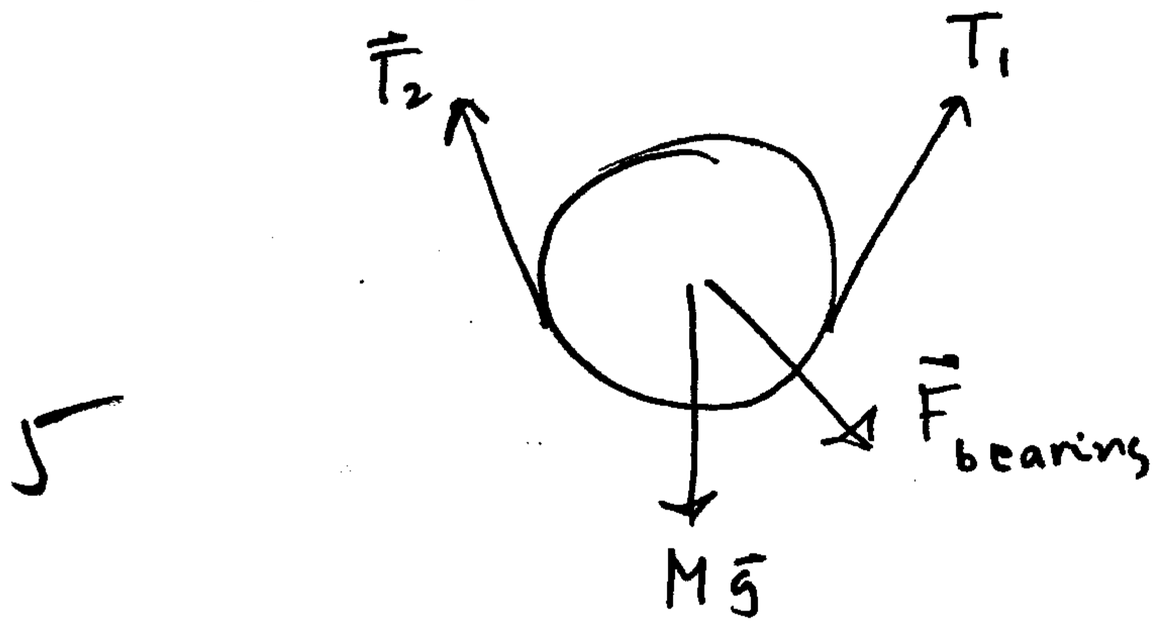
$I = 0.0075\ kgm^2$

$R = 0.10\ m$

$T_1 = 15\ N \quad T_2 = 20\ N$

$M = 1.5\ kg \quad \theta = 30°$

a) Draw a force diagram for the pulley.



Note $T_2 > T_1$

b) Calculate the net torque (vector - specify direction unambiguously) acting on the pulley. Use the origin (located at the center of the pulley) and co-ordinate system shown.

$$\tau = (T_2 - T_1)R$$
$$= (20-15)\,N\,(0.10\,m)$$
$$= 0.50\ N\,m\ \otimes$$

c) The pulley has an initial angular velocity of zero. After 1.0 minute, how many revolutions has the pulley made?

$$\Delta\theta = \frac{1}{2}\alpha t^2 \qquad \alpha = \frac{\tau}{I}$$

$$= \left(\frac{1}{2}\right)\left(\frac{0.50\ \text{Nm}}{0.0075\ \text{kg m}^2}\right)(60\text{s})^2\left(\frac{1\ \text{rev}}{2\pi}\right)$$

$$= 1.91 \times 10^4\ \text{rev}$$

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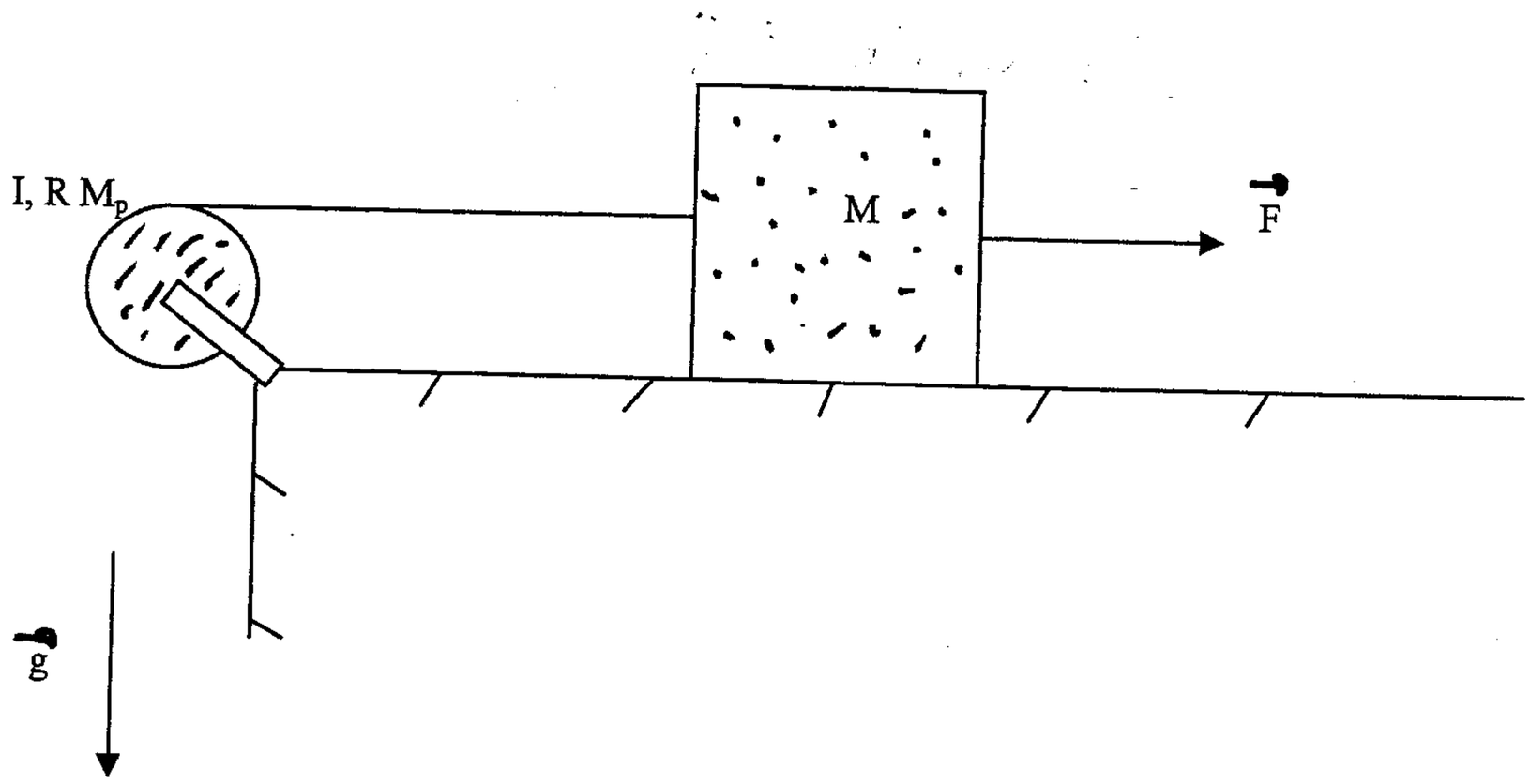
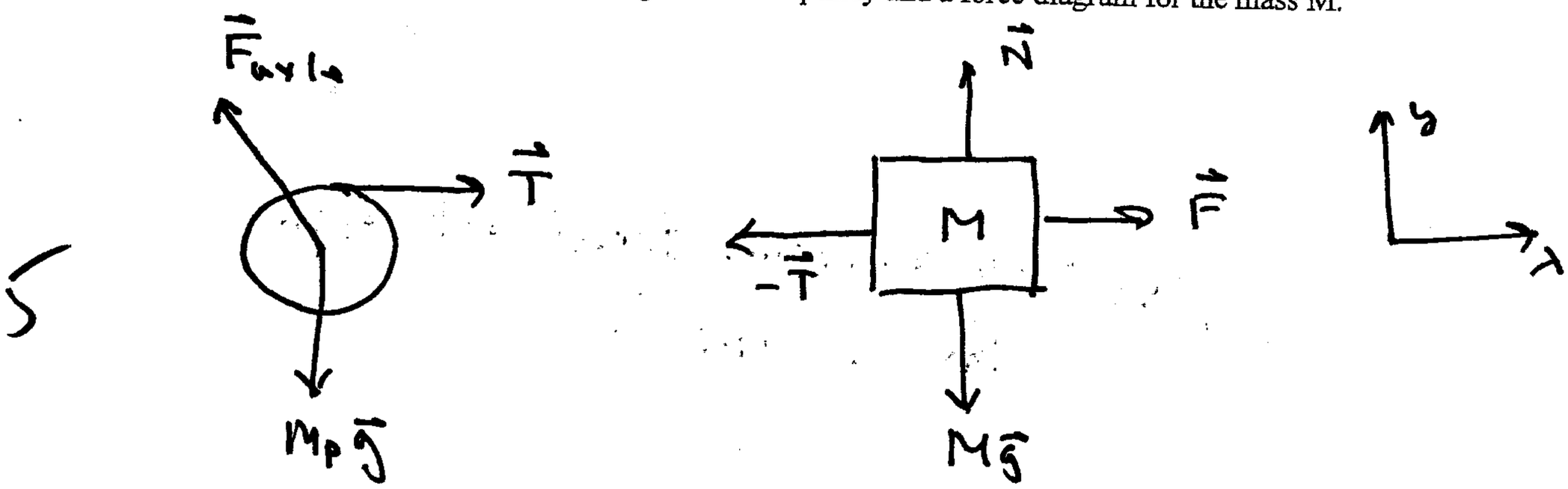
') (15 pts) The picture below shows a pulley mounted on a frictionless axis. The pulley has moment of inertia I, radius R, and mass M_p. A "physics string" is wrapped around the pulley and is attached to a block of mass M that slides on a horizontal frictionless surface. A horizontal force of magnitude F is applied to the block as shown. Assume that there is no slipping between the string and the pulley.



a) In the space provided, draw a force diagram for the pulley and a force diagram for the mass M.



b) Derive a formula for the acceleration of the mass M. The only symbols that should appear in your formula are the symbols on the diagram along with numerical factors like the number 2.

$$F - T = Ma \qquad T = F - Ma$$

$$I\alpha = RT \qquad \alpha = \frac{a}{R} \Rightarrow \frac{Ia}{R^2} = T$$

$$\frac{Ia}{R^2} = F - Ma$$

$$a = \frac{F}{M + I/R^2}$$

c) Drive a formula that gives the total torque acting on the pulley. Torque is a vector. Give the direction of the torque. The only symbols that should appear in your formula are the symbols on the diagram along with numerical factors like the number 2.

$$\tau = I\alpha = \frac{Ia}{R} \qquad a = \frac{F}{M + I/R^2}$$

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$$\tau = \frac{IF}{R(M + I/R^2)}$$ (X)