Physics 1145 Fall 2021 Test 2 (4 pages)

Name: Solution **October 20, 2021** **Total Score:** 120 **/120**

$\sum F_x = ma_x$ $\sum F_y = ma_y$ $f_S \leq \mu_S N$ $f_k = \mu_k N$ g= 9.8m/s^2

$a_c = \frac{v^2}{R}$ $v = \frac{2\pi R}{T}$=ωR $\omega = 2\pi f = \frac{2\pi}{T}$ $F_G = \frac{GmM}{r^2}$ G=6.67×10^{-11} Nm^2/kg^2

D 1. (5) You are bouncing on a trampoline. At the highest point of your motion, your apparent weight is

A) less than your true weight B) equal to your true weight

C) more than your true weight D) zero

B 2.(5) A flying mosquito collides head-on with a standing elephant. The magnitude of the force exerted by the mosquito on the elephant is ______________ the magnitude of the force exerted by the elephant on the mosquito during the collision:

A) smaller than B) equal to C) larger than D) not enough information

B 3. (5) A cat rests on a horizontal table. The reaction force to the weight force acting on the cat is

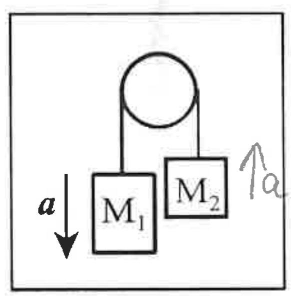
A) the normal force on the cat by the table.

B) the force of gravity by the cat on the Earth.

C) the force by the cat on the table.

D) There is no reaction force because the cat is at rest.

D 4. (5) Block 1 has mass M_1 and is connected to block 2 of mass M_2 by a massless rope that runs over a massless, frictionless pulley. The acceleration of block 1 has magnitude a and is directed downward. Which is true about the tension T in the rope?



A) $T = M_1 a$ B) $T < M_2 g$ C) $T = M_2 g$ D) $T > M_2 g$

B 5. (5) The free-fall acceleration on planet A is 12 m/s^2. The radius and mass of planet B are twice the radius and mass of planet A. The free-fall acceleration on planet B equals

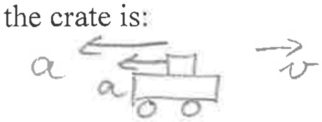
A) 3 m/s^2 B) 6 m/s^2 C) 12 m/s^2 D) 24 m/s^2

$g = \frac{GM}{R^2} \to \frac{G \cdot 2M}{(2R)^2} = \frac{1}{2} g$

B 6. (5) A pickup truck is approaching a red traffic light on a level road and is slowing down. A crate in the back of the truck does not slide. The force of friction produced on the crate is:

A) kinetic, aimed forward B) static, aimed backward

C) kinetic, aimed backward D) static, aimed forward



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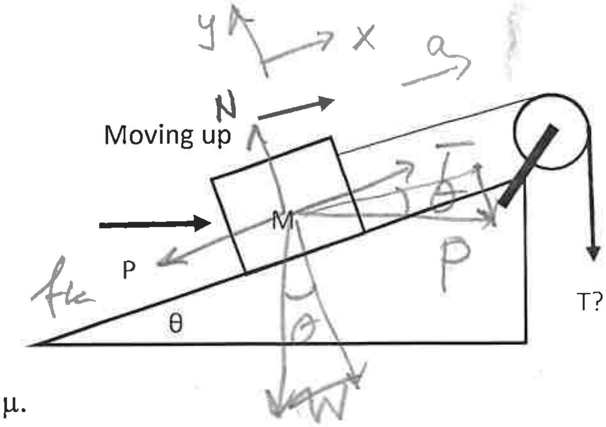
7.(30) Two people are moving a crate of mass M up a rough inclined ramp that makes an angle θ with the horizontal. One person applies a horizontal pushing force of constant magnitude P to the crate. The other person pulls with constant force T at the end of a rope that is tied to the crate and runs over a massless frictionless pulley. The crate moves **up** the ramp. The coefficient of kinetic friction between crate and ramp is μ.



a) In the figure, superimpose a fully labeled free-body diagram for the crate. Include all information necessary to solve parts b) below.

b) Derive an expression for the acceleration of the crate, in terms of P, T, M, g, μ, and θ.

$$\sum F_x = N_x^{0} + T_x + P_x + f_{kx} + W_x = Ma_x$$

$$T + P\cos\theta - f_k - Mg\sin\theta = Ma_x$$

$$f_k = \mu N$$

$$\sum F_y = N_y + T_y^{0} + P_y + f_{ky}^{0} + W_y = Ma_y^{0}$$

$$N - P\sin\theta - Mg\cos\theta = 0$$

$$N = P\sin\theta + Mg\cos\theta$$

$$\boxed{a_x = \frac{1}{M}\left[T + P\cos\theta - \mu(P\sin\theta + Mg\cos\theta) - Mg\sin\theta\right]}$$

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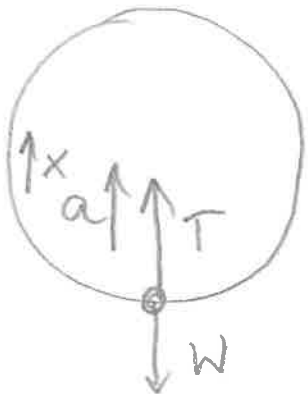
8. A ball of mass 100g is at the end of a string of length 0.5m and is twirled in a **vertical** circle.

a) The ball is at the **lowest point.**
Draw a free body diagram for the ball, including all information needed.
The ball is moving at a speed of 4.0m/s. Derive a symbolic expression for the tension in the string at this instant and calculate a numerical value.



$$\sum F_x = T_x + W_x = Ma_x$$

$$T - Mg = M\frac{v^2}{R}$$

$$\boxed{T = M\left(g + \frac{v^2}{R}\right)}$$

$$T = 0.1\,kg\left(9.8\,\frac{m}{s^2} + \frac{(4\,m/s)^2}{0.5\,m}\right) = 4.2\,N$$

b) The ball is now at the **top of the circle**.
Draw a free body diagram for the ball, including all information needed.
Derive a symbolic expression for the minimum speed at which the ball must move to prevent the string from going slack. Calculate a numerical value.

@ V_{min}: $T \to 0$

$$\sum F_x = W_x = Ma_x$$

$$Mg = M\frac{V_{min}^2}{R}$$

$$\boxed{V_{min} = \sqrt{gR}}$$

$$V_{min} = \sqrt{9.8\,\frac{m}{s^2} \cdot 0.5\,m} = 2.2\,m/s$$

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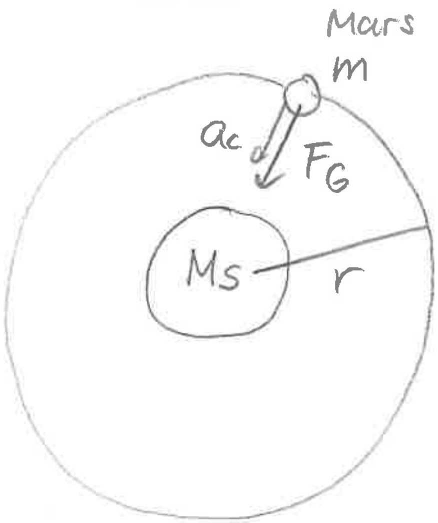
9.(30) Mars has a radius of 3.4×10^6 m and the free-fall acceleration on its surface is $3.7 m/s^2$.

It takes Mars 1.88 years to orbit the sun at a radius of 2.28×10^{11} m.

Find symbolic expressions and calculate numerical values for the mass of Mars and the mass of the sun.



Satellite Motion:

$$\sum F_+ = m a_+$$

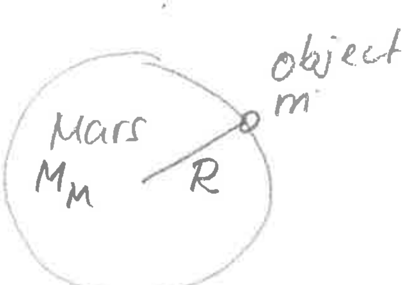
$$\frac{G M_s m}{r^2} = m \frac{v^2}{r}$$

$$\frac{G M_s}{r} = v^2 = \left(\frac{2\pi r}{T}\right)^2$$

$$\boxed{M_s = \frac{4\pi^2 r^3}{G T^2}}$$

$$M_s = \frac{4\pi^2 (2.28\times10^{11} m)^3}{6.67\times10^{-11} \frac{Nm^2}{kg^2} \cdot (1.88\cdot365\cdot24\cdot3600 s)^2}$$

$$M_s = 1.99\times10^{30} kg$$



$$\frac{G M_m m}{R^2} = m g_M$$

$$\boxed{M_m = \frac{g_M R^2}{G}}$$

$$M_M = \frac{3.7 \frac{m}{s^2} \cdot (3.4\times10^6 m)^2}{6.67\times10^{-11} \frac{Nm^2}{kg^2}} = 6.4\times10^{23} kg$$

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