# PHY 105 Test 2 November 1, 2005 Solutions

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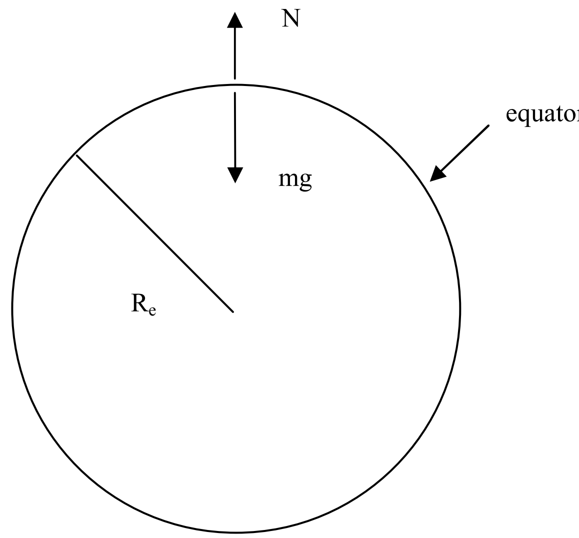
1. At the equator, the speed is given by $v = \dfrac{2\pi R_e}{T}$ where $R_e$ is the radius of the earth and T is the time it takes for the earth to rotate once, i.e. 1 day = 86400 s. Centripetal acceleration is therefore

$$a_c = \frac{v^2}{R_e} = \frac{4\pi^2 R_e}{T^2} = 0.0337 \text{ m}/s^2$$

At the North Pole there is no circular motion, and therefore $a_c = 0$

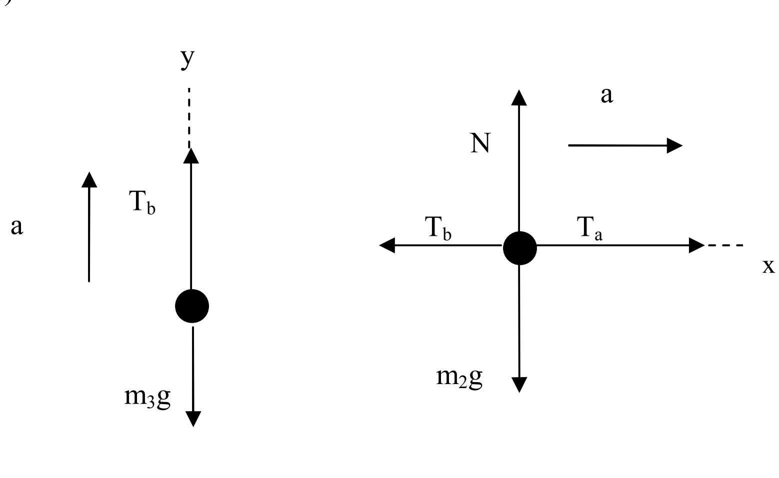



b) At the equator there must be a net force towards the center of the earth to provide for the centripetal acceleration there. Because mg and N are the only forces acting in the radial direction,

$\sum F = mg - N = m\dfrac{v^2}{R_e}$ and apparent weight *N* is less than your true weight (*mg*) by $ma_c$, or 2.53 N

c) At the North Pole there is no centripetal acceleration (there is rotation, but it is about a vertical axis through your body, perpendicular to the normal force), and therefore your apparent weight equals your true weight

2. a)




2b) Mass 1: $\sum F_y = m_1 g - T_a = m_1 a$

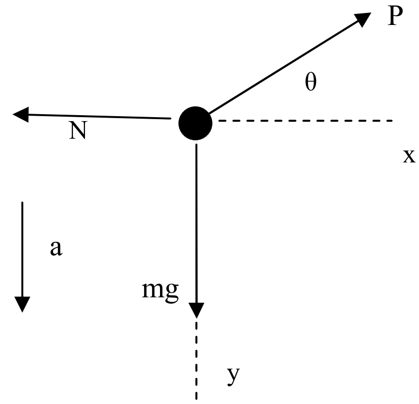
Mass 2: $\sum F_x = T_a - T_b = m_2 a$

Mass 3: $\sum F_y = T_b - m_3 g = m_3 a$

2c) Add Mass 1 and Mass 2 equations to eliminate Ta. This new expression can be added to Mass 3 equation to eliminate $T_b$, yielding

$$a = \frac{m_1 - m_3}{m_1 + m_2 + m_3} g$$

2d) The expression in (c) predicts that a=0 if $m_1 = m_3$, exactly what would happen because both masses tug equally on the mass in the middle.
The expression in (c) also predicts that $a \approx 0$ if $m_1$ is much more massive than the other masses. This is expected, because the behavior should mimic free-fall conditions.




3 a) From the free body diagram

$\sum F_y = mg - P\sin\theta = ma$ , where P = 38 N, m = 1.9 kg, and θ = 40°, therefore the acceleration is $a = g - \frac{P}{m}\sin\theta = -3.056 \text{ m/s}^2$

3b) The mass moves with constant acceleration a displacement d = 0.79 m and initial velocity of 3.7 m/s. The velocity after this displacement is then

$$v_f = \sqrt{v_i^2 + 2ad} = 2.98 \text{ m/s}$$

4a) Because the forces are constant, use the formula $W = \vec{F} \cdot \vec{d} = Fd\cos\theta$ to calculate work:

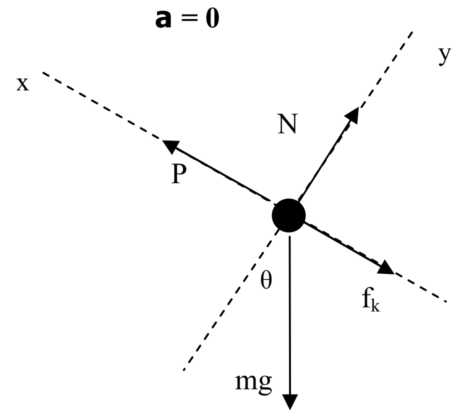
$$W_g = mgd\cos 0 = 14.7098 \text{ J}$$
$$W_P = Pd\cos 130 = -19.2965 \text{ J}$$

4b) Using Work-Kinetic Energy Theorem, $W_{Tot} = K_f - K_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$, and $W_{Tot} = W_g + W_P = -4.5867 \text{ J}$. The final velocity is therefore

$$v_f = \sqrt{v_i^2 + \frac{2}{m}W_{Tot}} = 2.98 \text{ m/s}$$

As necessary, this is the same answer as 3(b).

5 From the free body diagram




$$\sum F_x = P - mg\sin\theta - f_k = 0$$
$$\sum F_y = N - mg\cos\theta = 0$$

Solving for N from the y-equation yields

$N = mg\cos\theta$. This allows the kinetic friction force to be calculated using $f_k = \mu_k N$. This force is then substituted into the x-equation and allows P to be calculated:

$$\begin{aligned} P &= mg\sin\theta + \mu_k mg\cos\theta_k \\ &= mg\left(\sin\theta + \mu_k\cos\theta\right) \end{aligned}$$

With m = 2.0 kg, $\mu_k = 0.3$ and $\theta = 30°$, P = 14.89 N