Name___________________________________

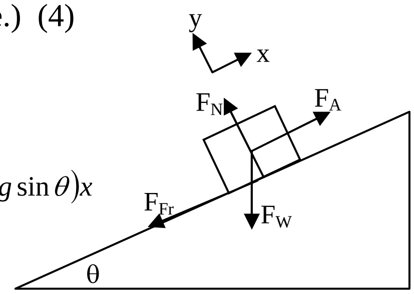
Physics 120 Quiz #4, May 2, 2007

1. Physicians usually administer stress-tests to determine if patients have any cardiac related problems or disease. To measure the cardiac function, physicians examine the beating heart first with the patient at rest and then again while the heart is under stress. To put the patient under stress the physician has the patient run, usually, on a treadmill. Suppose that a *50 kg* patient is running at a constant speed of *4 m/s* for *5 minutes* on a treadmill that is inclined at 30^o with respect to the horizontal, and that the patient exerts a constant *500 N* force up the slope of the treadmill.

   a. How much distance has the patient covered in these 5 minutes? (2)

   $$x = vt = 4\tfrac{m}{s} \times 300s = 1200m$$

   b. Suppose that there exists a frictional force between the patient and the treadmill with a coefficient of friction 0.45, how much work was done by the patient running on the treadmill? (Hint: You will need to use a carefully labeled free-body diagram to determine the net force.) (4)



   $$\sum F_x : \ F_{net,x} = 500N - F_{fr} - F_{W,x}$$
   $$\sum F_y : \ F_{net,y} = 0$$
   $$W = F_{net,x}x = \left(500N - F_{fr} - F_{W,x}\right)x = \left(500N - \mu_k mg\cos\theta - mg\sin\theta\right)x$$
   $$\therefore W = \left(500N - 190.95N - 245N\right)\times 1200m = 7.7\times 10^4 J$$

   c. What was the rate at which energy was expended by the patient (from their food stores as chemical energy)? (Hint: What was the power output of the patient?) (2)

   $$P = \frac{dE}{dt} = \frac{7.7\times 10^4 J}{300s} = 256.7W$$

2. A golfer badly misjudges a put, sending the ball only ¼ of the distance to the hole. If the original speed of the ball were v_0, and if the resistive force of the grass on the ball is constant, the speed needed to get the ball to the hole would have needed to be

   a. 2 v_0. b. 3 v_0. c. 4 v_0 . d. 5 v_0.

$$W = -Fd = \Delta KE = -\tfrac{1}{2}mv_0^2 \rightarrow v_0^2 = \frac{2Fd}{m}, \text{ so to go 4d, } v_{new}^2 = \frac{2F(4d)}{m} = 4v_0^2 \rightarrow v_{new} = 2v_0$$

Useful formulas:

Motion in the x, y or z-directions

$r_f = r_0 + v_{0r}t + \frac{1}{2}a_r t^2$

$v_{fr} = v_{ir} + a_r t$

$v_{fr}^2 = v_{ir}^2 + 2a_r \Delta r$

Uniform Circular Motion

$a_r = \frac{v^2}{r}$

$F_r = ma_r = m\frac{v^2}{r}$

$v = \frac{2\pi r}{T}$

$F_G = G\frac{m_1 m_2}{r^2}$

Geometry /Algebra

Circles	*Triangles*	*Spheres*
$C = 2\pi r$	$A = \frac{1}{2}bh$	$A = 4\pi r^2$
$A = \pi r^2$		$V = \frac{4}{3}\pi r^3$

Quadratic equation: $ax^2 + bx + c = 0,$

whose solutions are given by: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

magnitude of a vector $= \sqrt{v_x^2 + v_y^2}$

direction of a vector $\rightarrow \phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

Useful Constants

$g = 9.8\, m/s^2$ $\quad G = 6.67 \times 10^{-11}\, Nm^2/kg^2$

$N_A = 6.02 \times 10^{23}\, atoms/mole$ $\quad k_B = 1.38 \times 10^{-23}\, J/K$

$\sigma = 5.67 \times 10^{-8}\, W/m^2K^4$ $\quad v_{sound} = 343\, m/s$ $\quad P_{air} = 1.013 \times 10^5\, N/m^2$

Linear Momentum/Forces

$\vec{p} = m\vec{v}$

$\vec{p}_f = \vec{p}_i + \vec{F}\Delta t$

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

$\vec{F}_s = -k\vec{x}$

$F_f = \mu F_N$

Work/Energy

$K_t = \frac{1}{2}mv^2$

$K_r = \frac{1}{2}I\omega^2$

$U_g = mgh$

$U_S = \frac{1}{2}kx^2$

$W_T = FdCos\,\theta = \Delta E_T$

$W_R = \tau\theta = \Delta E_R$

$W_{net} = W_R + W_T = \Delta E_R + \Delta E_T$

Rotational Motion

$\theta_f = \theta_i + \omega_i t \frac{1}{2}\alpha t^2$

$\omega_f = \omega_i + \alpha t$

$\omega^2{}_f = \omega^2{}_i + 2\alpha\Delta\theta$

$\tau = I\alpha = rF$

$L = I\omega$

$\Delta s = r\Delta\theta: \; v = r\omega: \; a_t = r\alpha$

$a_r = r\omega^2$

Simple Harmonic Motion/Waves

$\omega = 2\pi f = \frac{2\pi}{T}$

$T_S = 2\pi\sqrt{\frac{m}{k}}$

$T_P = 2\pi\sqrt{\frac{l}{g}}$

$v = \pm\sqrt{\frac{k}{m}}A\left(1 - \frac{x^2}{A^2}\right)^{\frac{1}{2}}$

$x(t) = A\sin\left(\frac{2\pi t}{T}\right)$

$v(t) = A\sqrt{\frac{k}{m}}\cos\left(\frac{2\pi t}{T}\right)$

$a(t) = -A\frac{k}{m}\sin\left(\frac{2\pi t}{T}\right)$

$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$

$f_n = nf_1 = n\frac{v}{2L}$

$P = \frac{1}{2}\omega^2\mu vA^2$