Physics 180

Term Test #2 **November 8, 2007**

1)

i) Centripetal force is an inward radial force that is associated with an object moving in a circle. Centrifugal force is a fictitious force which one uses in the non-inertial rotating frame of reference, with magnitude the same as the centripetal force but in the opposite direction.

ii) The thrust of a rocket is the force exerted on it by the ejected material. It is the product of the rate at which exhaust is ejected and the speed, relative to the rocket, at which exhaust is ejected.

iii) The terminal speed of an object is the speed a falling object attains when the force of gravity is balanced exactly by the resistive force.

iv) A non-conservative force is one for which the work done depends on the detailed path taken.

v) For a particle to be in stable equilibrium the net force on it must be zero and its potential energy must be a local minimum (second derivative of potential is positive).

2) i) By examining the suspended object $T - m_2 g = 0$ and the tension in the string is m_2g.

ii) The radial force acting on the object is also m_2g.

iii) The speed of the object is found from $m_2 g = m_1 v^2 / R$ or $v = \sqrt{R m_2 g / m_1}$.

iv) The mass m_2 drops, the tension increases, the centrifugal force increases, the radius shrinks and the mass m_1 increases in speed. A new steady-state situation develops.

3) i) Let L be the length of the chain on the table so $8\text{-}L$ is the length of the chain hanging off the edge. Take the positive direction to be directed toward the front of the chain. If the object is in equilibrium the frictional force on the chain from the table plus the gravitational force on the chain is zero or

$$-\mu_s Mg \frac{L}{8} + \frac{8-L}{8} Mg = 0 \quad \text{for the maximum frictional force}$$

For the quantities given $8\text{-}L = 3m.$

ii) The y (vertical) co-ordinate of the Center of mass, with $y = 0$ being the table top,

is $$\frac{M_{table} y^{cm}_{table} + M_{hanging} y^{cm}_{hanging}}{M_{table} + M_{hanging}} = \frac{M\frac{5}{8}(0) + \frac{3}{8}M(-1.5)}{M} = -4.5/8 = -0.56m$$

iii) The total force along the chain once it begins to move is the force of friction and the force of gravity on the hanging end or $-\mu_k Mg \frac{x}{8} + \frac{8-x}{8} Mg$ where x is the length of the chain on the table at any time with x varying from 0 to 5. The total work done is

$$\int_0^5 \left[-\mu_k Mg\frac{x}{8} + \frac{8-x}{8}Mg\right]dx = \frac{Mg}{8}\int_0^5 \left[8-(1+\mu_k)x\right]dx = \frac{Mg}{8}(40-(1.6)(12.5)) = 25J = \frac{1}{2}Mv_f^2$$

and so v_f=*7.1m/s.*

iv) The force on the chain is the normal force required to support the weight of the chain on the floor plus the force necessary to change the momentum of the falling portion of chain. The former is $F_1 = \frac{6}{8}Mg$=7.5N while the latter is defined by $F - \frac{2}{8}Mg = \frac{d(M_{chain}v)}{dt} = \frac{-2}{8}M\frac{dv}{dt} + v\frac{dM}{dt}$ or $F = \frac{dM}{dt}v = \lambda\frac{dl}{dt}v = \lambda v^2$ where λ is the density of the chain, l is the instantaneous length above the floor and v is the velocity of the chain when 2m of the chain is off the floor. But the chain had a speed of v_i =7.1m/s when it left the table. When the end falls -6 m using $v_f^2 - v_i^2 = 2(y)(-g)$, we find that the chain has a speed of 13/s. Hence the total force is $F_1 + F$ = 7.5 N+21.3N=29 N.

4) i) *See Serway P.174*

ii) *See Serway P.205* together with the fact that the work done by conservative forces is

$$W_C = \int_{\vec{r}_i}^{\vec{r}_f} \vec{F}_C \cdot d\vec{r} = -[U(\vec{r}_f) - U(\vec{r}_i)] = -[U_f - U_i].$$

iii) In an frame of reference one has for a perfectly inelastic collision the two objects stick together so that

$$m_1v_1 + m_2v_2 = (m_1+m_2)v_f = (m_1+m_2)v_{cm}$$

where the last result follow from the definition of center of mass or center of mass velocity. In the center of mass frame of reference after the collision both objects come to rest (since they stick together) and so in this frame all the initial kinetic energy is lost.