Phys 1501 Review 2

1) sliding Blocks

Strategy

Look at 2 blocks seperately (look at diagram on screen)

Top block has a contact force exerted by the bottom block

Normal Force N_1 and Frictional force $-.4N_1$ (using coefficient of friction)

Other forces are tension from string + weight (gravity)

Bottom block has $-N_1$ and $.4N_1$ with top block

N_2 and $.4N_2$ with floor

other forces: $-P$ (applied force), tension, and weight

Solution

Constant speed = no acceleration

Newton's second law: $\sum F = ma \rightarrow \sum F_x = m_1 a_x$ $\quad \sum F_y = m_1 a_y$

Top $\quad T - .4N_1 = 0 \quad N_1 - 19.6N = 0$

$N_1 = 19.6 \quad T = 7.84N$

Bottom $\quad \sum F_x = m_1 a_x = 0 \quad \sum F_y = m_1 a_y = 0$

$T - P + .4N_1 + .4N_2 = 0 \quad N_2 - 39.2N - N_1 = 0$

$N_2 = 58.8N \quad P = 39.2N$

2) Power

Stategy

constant velocity (90km/h) so net $\overset{F\cdot d}{\text{work}} = 0$

$\text{Power (engine)} = \underset{\overset{\uparrow}{75\%}}{\text{gravity}} + \underset{\overset{\uparrow}{25\%}}{\text{air resistance}}$

$m\vec{g}\cdot\vec{v} = mgv\sin\theta$

15% grade → $\tan\theta = .15$

Solution

$P = m\vec{g}\cdot\vec{v} = mgv\sin\theta$

$.75P = mgv\sin(\tan^{-1}(.15))$

$$P = \frac{(1200\cdot 9.8)(90m/\overset{\swarrow \text{ from km/h}}{3.65})\sin(8.53)}{.75} = 58kW\ (78hp)$$

)Center of Mass

Strategy

Use center of earth as center of system

Solution

$$R = \frac{m_e r_e + m_m r_m}{m_e + m_m} \qquad \overset{\downarrow}{r_e = 0\,m} \qquad R = \frac{(5.97E24)(0) + (7.36E22)(3.82E8)}{5.97E24 + 7.36E22} = 4.64E6$$

Radius of earth is 6.37E6 so $-4.64E6$ means a $\overset{\curvearrowright 1000\,\text{miles}}{1.73E6\,m}$ radius for system below earths surface

4) Conservation of momentum

a) We want conservation of momentum so we need a closed system

System: hammer + Iron man from collision to right before hitting tree

M_H = mass of hammer

M_I = mass of Iron man

V_H = velocity of hammer befor hitting Iron Man

V = combined velocity of Iron man + Hammer after collision

$$\overset{\text{Iron Man}}{V_0 = 0} \qquad \overset{\text{momentum}}{M_H V_H = (M_H + M_I)V} \rightarrow \overset{\text{For mass of hammer}}{M_H V_H = M_H V + M_I V} \rightarrow M_H(V_H - V) = M_I V$$

$$M_H = \frac{M_I V}{V_H - V} = \frac{200kg\left(\frac{2m}{.75s}\right)}{10\frac{m}{s} - \left(\frac{2m}{.75s}\right)} = 73kg$$

Momentum conserved

b) KE initial → $K_i = \frac{1}{2} M_H V_H^2$ ← all in the hammer

$= \frac{1}{2}(70kg)(10m/s)^2$

$= 3500\,J$

$K_f = \frac{1}{2}(M_H + M_I)V^2$

$= \frac{1}{2}(70kg + 200kg)(2.67m/s)^2$

$= 960\,J$

$K_f - K_i = 3500J - 960J = 2540J$ Energy not conserved

5) Inelastic Collisions

strategy

Define the system to be 2 particles. Inelastic collision because they stick. Momentum conserved, KE is not

Solution

$MV_p - MV_n = 2MV_d$ $\rightarrow V_p - V_n = 2V_d$ $\quad 7E6 - 4E6 = 2V_d$

$\vec{V}_d = (1.5E6\,m/s)\underset{\text{x direction}}{\hat{i}}$ $\quad V_d = 1.5E6\,m/s$

6) Rotational Kinematics

strategy

a) $\underset{\text{average angular accel}}{\bar{\alpha}} = \frac{\overset{\text{angular velocity}}{\Delta\omega}}{\Delta t}$ $\qquad \Delta\omega = \omega_f - \omega_i = 250\ \text{rev/min} \quad \Delta t = 5$

$\downarrow$

b) Know α and $\Delta\omega$ $\qquad$ stopping time $\Delta t = \frac{\Delta\omega}{\alpha}$

Solution

a) $\alpha = \frac{\Delta\omega}{\Delta t} = \frac{250\text{rpm}}{5}$ $\qquad$ Need rad/s from rpm

$\Delta\omega = 250\ \frac{\text{rev}}{\text{min}} \cdot \frac{2\pi\ \text{rad}}{\text{rev}} \cdot \frac{1\text{min}}{60\text{sec}} = 26.2\ \text{rad/sec}$

$\alpha = \frac{26.2\ \text{rad/s}}{5\ \text{s}} = 5.24\ \text{rad/s}^2$

b) ω goes from 26.2 rad/s to 0 $\rightarrow \Delta\omega = -26.2$ rad/s

$\Delta t = \frac{-26.2\text{rad/s}}{-87.3\ \text{rad/s}^2} = .3\ \text{sec}$

7) Moment of inertia

Strategy / Solution

a) Definition of inertia for a system and sum

$$I = \sum_j \overset{\leftarrow \text{constant}}{m_j} r_j^2 = (.02kg)(2(.25m)^2 + 2(.15m)^2 + 2(.05m)^2) = .0035\ kg\,m^2$$

b) $I = \sum_j m_j r_j^2 = (.02kg)(2(.25)^2 + 2(.15)^2) = .0034\ kg\,m^2$ ← very similar

c) Rotational kinetic energy $(K) = \frac{1}{2} I \omega^2$

$$K = \frac{1}{2} I \omega^2 = \frac{1}{2}(.0035 kg\,m^2)(5 \cdot 2\pi\ rad/s)^2 = 1.73\ J$$

8) Torque

Strategy

Find each torque individually (using cross product) + determine sign. Then add

Solution

$\vec{F}_1$ is opposed so $180 - 30 = 150°$

RHR is out of page (positive)

$|\vec{\tau}_1| = r F_1 \sin 150 = .5m(20N)(.5) = 5\ Nm$

$\vec{F}_2$ is at $90°$

RHR is into page (negative

$|\vec{\tau}_2| = -r F_2 \sin 90 = -.5m(30N) = -15\ Nm$

$\vec{F}_3$ is at $0°$ ⇒ No torque $(\sin 0 = 0)$

$\tau_{net} = \sum_i |\vec{\tau}_i| = 5 - 15 = -10\ Nm$