Physics 200 Name KEY

Final Exam

December 12, 2005

This is a closed book examination. There is extra scratch paper available. Explain all answers completely – show your thoughts and work!

1) [10 pts] You have a spring with a small mass attached that has an oscillation frequency, *f*, when it is bounced vertically. If you cut your spring in 3 equal parts and use one of these shorter springs with the same mass the new oscillation frequency is
   a) Less – $\frac{1}{\sqrt{3}}f$
   b) Less – $\frac{1}{3}f$
   c) The same – f
   [✓ d)] Greater – $\sqrt{3}f$
   e) Greater – $3f$

$\omega = 2\pi f$ $\omega = \left(\frac{k}{m}\right)^{1/2}$ so $f = \frac{1}{2\pi}\left(\frac{k}{m}\right)^{1/2}$

when spring is shortened k increases $k' = 3k$ $m' = m$

$f' = \frac{1}{2\pi}\left(\frac{k'}{m'}\right)^{1/2} = \frac{1}{2\pi}\left(\frac{3k}{m}\right)^{1/2} = \sqrt{3}\,\frac{1}{2\pi}\left(\frac{k}{m}\right)^{1/2} = \sqrt{3}f$

2) [10 pts] You throw a light ball into the air at an angle of θ to the horizontal. After the ball leaves your hand it travels a vertical distance *y*. You toss another ball that has 9 times the mass of the first ball into the air again exactly as you did before except you throw this ball with 3 times the initial velocity. The resulting vertical distance is
   a) Less – $\frac{1}{3}y$
   b) Less – $\frac{1}{9}y$
   c) The same – y
   d) Greater – $3y$
   [✓ e)] Greater – $9y$

$mgh = \frac{1}{2}mv_y^2$ – height is independent of mass

$h = \frac{v_y^2}{2g}$ $v_y' = 3v_y$ so $h' = \frac{(3v_y)^2}{2g} = 9\,\frac{v_y^2}{2g} = 9h$

3) [10 pts] You have a ring and a solid disk that both have the same radius. However, the disk has four times the mass of the ring. If these objects were to roll without slipping down a 7° ramp which one would reach the bottom first?
   a) The ring $I_1 = m_1r^2$
   [✓ b)] The disk $I_2 = \frac{1}{2}m_2r^2$ smaller "coefficient" means it is faster –(see work)
   c) They would reach the bottom at the same time
   d) They would not reach the bottom, the ramp needs to be steeper

4) [10 pts] You are pushing a box horizontally across the floor at a constant velocity of 2 m/s. You get tired and start pushing with half the original force. If the box travels 2 meters after you get tired, what is the kinetic coefficient of friction? $\mu_K = 0.2$

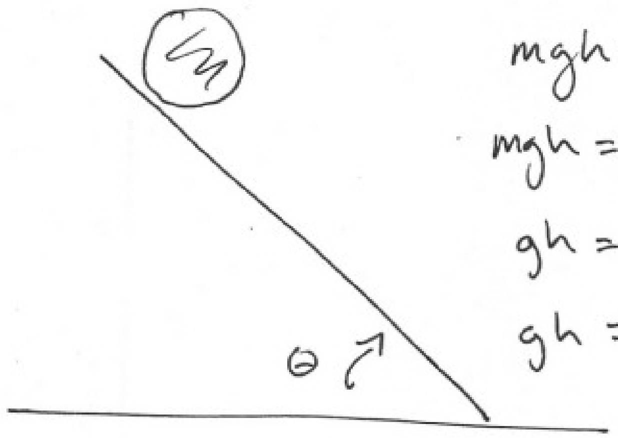
5) [10 pts] What is the escape velocity for a 3.14×10^4 kg rocket launched from earth?
(independent of mass) $V_{esc} = 11$ km/sec

6) [10 pts] An amusement park is testing the failure modes of their new roller coaster. They release an empty 3-car chain from the top of a 50 m tall ramp. At the bottom of the ramp is a horizontal section of track 10 m long. In the middle of this section is a 2-car chain. Following the flat section is a ramp that carries the cars to the top of a 20 m tall hill. If the first 3 empty cars were to stick to the bottom cars would the resulting 5-car chain make it over the second ramp? Assume negligible friction.

7) [10 pts] If $\Sigma F = 0$ on an object, can it stop spinning? If $\Sigma\tau = 0$ on an object, can it accelerate? Can an object be moving if $\Sigma F = 0$ and $\Sigma\tau = 0$? Explain.

FINAL EXAM

#3 In general



$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}Amr^2\omega^2$

$gh = \frac{1}{2}v^2 + \frac{1}{2}A(r^2\omega^2)$

$gh = \frac{1}{2}v^2 + \frac{1}{2}Av^2 = \frac{(1+A)}{2}v^2$

$v = \omega r$

$I = Amr^2$

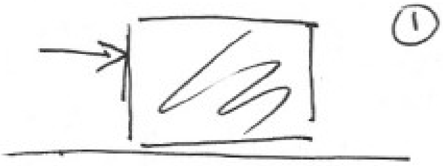
A is a coefficient dependant on object geometry

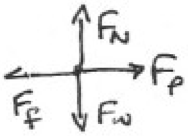
$v^2 = \frac{2gh}{(1+A)}$ smaller A means greater velocity —

- Note: result is independent of mass and radius of object

#4

$\Sigma F = ma$





① Initially $\Delta v = 0$ $v_i = 2\frac{m}{s}$ since

$F_p - F_f = 0$ so $F_p = F_f = \mu_k F_N = \mu_k F_w$

$F_N - F_w = 0$

$d = 2m$

$v_0 = 2m/s$

$a = -\frac{1}{2}\mu_k g$

$v = 0 m/s$ stops

② $\frac{1}{2}F_p - F_f = ma$ $F_N - F_w = 0$ $F_w = mg$

$\frac{1}{2}(\mu_k F_w) - \mu_k F_w = ma$ so $a = -\frac{1}{2}\mu_k g$

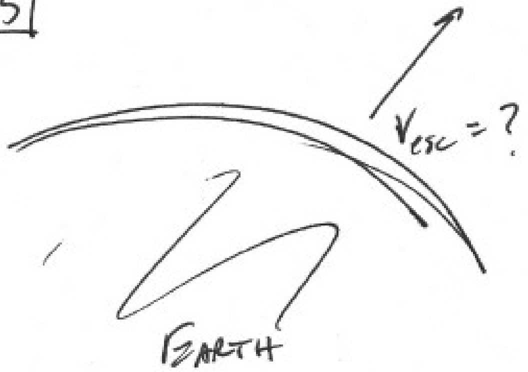
Using knematics

$x = x_0 + v_0 t + \frac{1}{2}at^2$ and $v = v_0 + at$ we find

$v^2 - v_0^2 = 2ad$ so $\frac{v_0^2}{2d} = \frac{\mu_k g}{2}$ so $\mu_k = \frac{v_0^2}{(dg)}$

$\boxed{\mu_k = 0.2}$

#5



$$E_i = E_f$$

$$\frac{1}{2}mv^2 + \frac{-GM_Em}{R_E} = 0 \qquad @\ R=\infty\ \ PE_G = 0$$

$$\frac{1}{2}mv^2 = \frac{GM_Em}{R_E}$$

$$v^2 = \frac{2GM_E}{R_E}$$

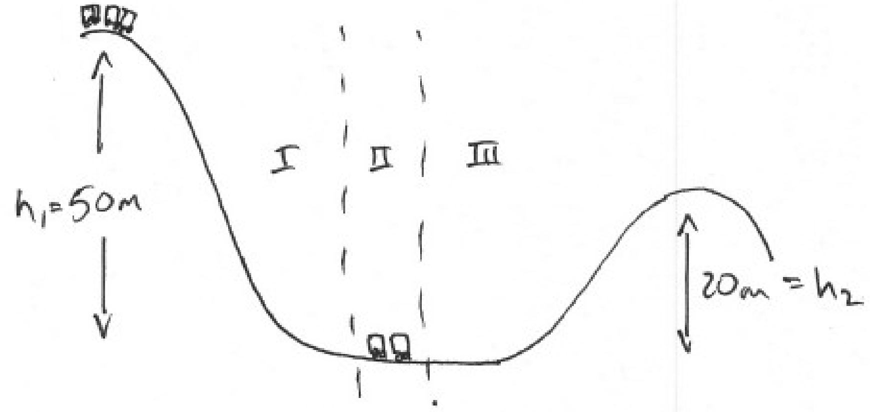
$$v = \left(\frac{2GM_E}{R_E}\right)^{1/2} = \left(2\cdot 6.67\times10^{-11}\frac{Nm^2}{kg^2}\cdot\frac{5.98\times10^{24}\,kg}{6370\times10^{3}\,m}\right)^{1/2} = 1.119\times10^{4}\ m/s$$

V_{escape} = 11,190 m/s or 25,179 mph

Note: units work ✓ V_{escape} is independent of mass

(However, energy required is dependendent on mass)

#6



I: Energy Conservation $\frac{1}{2}mv_1^2 = mgh_1$ $v_1 = (2gh_1)^{1/2}$ or $v_1^2 = 2gh_1$

II: Momentum Conservation $(3m)v_1 = (5m)v_2$ $v_2 = \frac{3}{5}v_1$

III: Energy Conservation $\frac{1}{2}m'v_2^2 = m'gh_2$ $h_2 = \frac{v_2^2}{2g}$

$$h_2 = \frac{(\frac{3}{5}v_1)^2}{2g} = \left(\frac{3}{5}\right)^2\frac{2gh_1}{2g} = \left(\frac{3}{5}\right)^2 h_1 \qquad h_2 = \frac{9}{25}\cdot 50m = 18m$$

units ✓

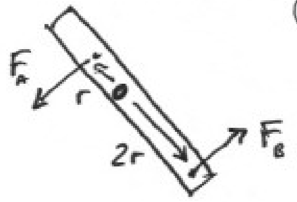
5cars do not make it over the 20m tall hill

#7

$\sum \vec{F} = m\vec{a}$ and $\sum \vec{\tau} = I\vec{\alpha}$

ⓐ If $\sum \vec{F} = 0$ an object could have $\sum \tau \neq 0$ so it could have a non-zero angular accel. and either speed up or slow down its rotation

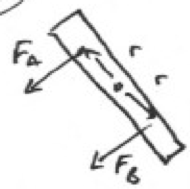
Example:



$F_A = -F_B$ but τ_A and τ_B want to rotate in the same direction

ⓑ If $\sum \vec{\tau} = 0$ an object could have $\sum F \neq 0$ so it would have a net acceleration

Example



$F_A = F_B$ but $\tau_A = -\tau_B$ object moves

ⓒ If $\sum \vec{F} = 0$ and $\sum \vec{\tau} = 0$ then acceleration and angular acceleration are zero

$a = 0 \rightarrow \Delta v = 0$

$\alpha = 0 \rightarrow \Delta \omega = 0$

This means an object can be moving but will not speed-up or slow-down.

- constant velocity
- constant ~~rotational spe~~ angular velocity (rotation speed)