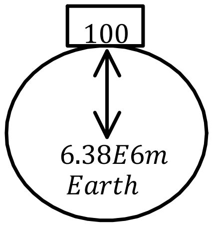
$$F_g = \frac{Gm_1m_2}{r^2}$$ $$E_{p\infty} = -\frac{GMm}{r}$$

P12 - 7.1 - Fg Ep Notes

F_g: *The Gravitational Force between any two Objects anywhere in the Universe. (Newton)*

E_p: *The Potential Energy a massive object has in relation to another due to gravity. (Joules)*

Distance from Earth



$$F_g = \frac{Gm_1m_2}{r^2}$$

$$g = \frac{GM}{r^2}$$

$$F_g = \frac{6.67\times10^{-11}(5.98\times10^{24})(100)}{(6.38\times10^6)^2}$$

$$F_g = 979.9\ N$$

$$F_g = mg$$
$$F_g = 100\times9.8$$
$$F_g = 980\ N$$

$$E_p = gmr$$
$$W = mgh$$
Obviously:)!

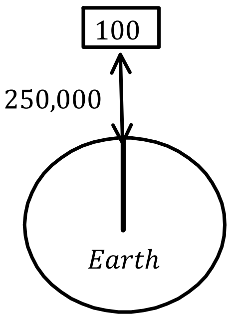
$$E_p = -\frac{GMm}{r}$$

$$E_p = -\frac{6.67\times10^{-11}(5.98\times10^{24})(100)}{6.38\times10^6}$$

$$E_p = -6.25\times10^9\ J$$

$$E_p = mgh$$
$$E_p = mg(0)$$
$$E_p = 0\ J$$

$$mgh = E_{pf} - E_{pi}\ ; r < 10000m$$



$$F_g = \frac{Gm_1m_2}{r^2}$$

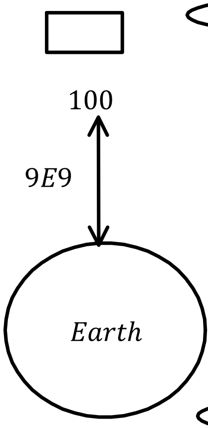
$$F_g = \frac{6.67E-11(5.98E24)(100)}{(6.38E6+250000)^2}$$

$$F_g = 907.4\ N$$

$$E_p = -\frac{GMm}{r}$$

$$E_p = -\frac{6.67E-11(5.98E24)(100}{6.38E6+250000}$$

$$E_p = -6.01E9\ J$$



$$F_g = \frac{Gm_1m_2}{r^2}$$

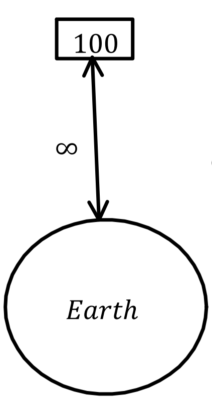
$$F_g = \frac{6.67E-11(5.98E24)(100)}{(6.38E6+9E9)^2}$$

$$F_g = 4.92E-4\ N$$

$$E_p = -\frac{GMm}{r}$$

$$E_p = -\frac{6.67E-11(5.98E24)(100)}{6.38E6+9E9}$$

$$E_p = -2.58E6\ J$$



$$F_g = \frac{Gm_1m_2}{r^2}$$

$$F_g = \frac{6.67E-11(5.98E24)(100)}{(6.38E6+\infty)^2}$$

$$F_g = 0\ N$$

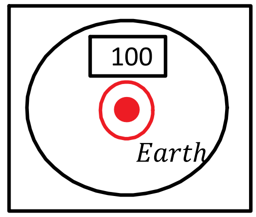
∞

$$E_{p\infty} = -\frac{GMm}{r}$$

$$E_{p\infty} = -\frac{6.67E-11(5.98E24)(100)}{6.38E6+\infty}$$

$$E_{p\infty} = 0\ J$$

E_p : Farther from Earth less negative!



Near Centre

$F_g \approx \infty N$

Surface

$F_g = 980N$

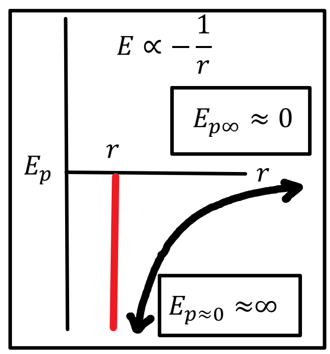
Far Away

$F_g \approx 0.0005N$

At Infinity

$F_g \approx 0N$

Weaker



Near Centre

$E_p \approx -\infty J$

Surface

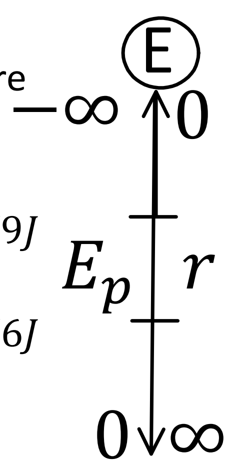
$E_p \approx -6E9J$

Far Away

$E_p \approx -3E6J$

At Infinity

$E_p \approx 0J$

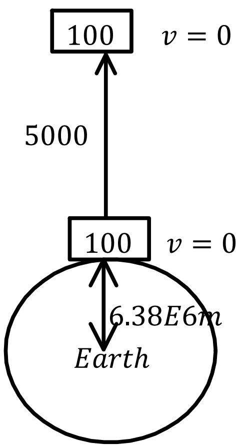


P12 - 7.2 - Fg Ep Work to Height Notes

What is the Gravitational Force, F_g, and Potential Energy between twins of 50kg 5 m apart?

$$F_g = \frac{Gm_1m_2}{r^2}$$
$$F_g = \frac{(6.67 \times 10^{-11})(50)(50)}{((5)^2)}$$
$$F_g = 6.67 \times 10^{-9}\ N$$

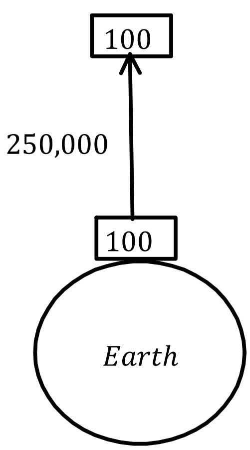
$$E_p = -\frac{GMm}{r}$$
$$E_p = -\frac{6.67E-11(50)(50)}{5}$$
$$E_p = 3.36E-8\ J$$



$$W = \Delta E$$
$$W = \Delta E_k + \Delta E_p$$
$$W = \Delta E_p \qquad ; E_k = 0$$
$$W = E_{pf} - E_{pi}$$
$$W = -\frac{GMm}{r_f} - -\frac{GMm}{r_i}$$
$$W = -\frac{6.67E-11(5.98E24)(100)}{6.38E6+5000} - -\frac{6.67E-11(5.98E24)(100)}{6.38E6}$$
$$W = -6246922475 - -6251818182\ J$$
$$W = 4895707$$
$$W = 4.89 \times 10^6\ J$$

$$W = GMm\left(\frac{1}{r_i} - \frac{1}{f}\right)$$

$$E_p = mgh$$
$$E_p = 100(9.8)(5000)$$
$$E_p = 4.9 \times 10^6\ J$$



$$W = \Delta E$$
$$W = \Delta E_k + \Delta E_p$$
$$W = \Delta E_p$$
$$W = E_{pf} - E_{pi}$$
$$W = -\frac{GMm}{R} - -\frac{GMm}{r}$$
$$W = -\frac{6.67E-11(5.98E24)(100)}{6.38E6+250000} - -\frac{6.67E-11(5.98E24)(100)}{6.38E6}$$
$$W = -6016078431 - -6251818182\ J$$
$$W = 235739751$$
$$W = 2.36 \times 10^8 J$$

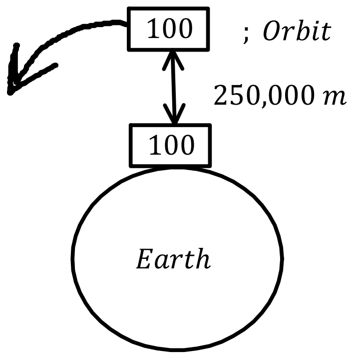
$$E_p \neq mgh\ ;\ h > 10000m$$

$$E_{pi} + E_{ki} + \Delta E = E_{pf} + E_{kf}$$
$$E_{pi} + E_{ki} + W = E_{pf} + E_{kf}$$
$$W = (E_{pf} - E_{pi}) + (E_{kf} - E_{ki})$$

$$W = \Delta E$$

$$W = \Delta E$$
$$W = \Delta E_p + \Delta E_k$$
$$W = (E_{pf} - E_{pi}) + (E_{kf} - E_{ki})$$

P12 - 7.3 - Velocity in/Work to Orbit Notes



$$F_g = F_c$$
$$\frac{GMm}{r^2} = ma_c$$
$$\frac{GMm}{r^2} = m\frac{v^2}{r}$$
$$\frac{GM}{r} = v^2$$
$$v = \sqrt{\frac{GM}{r}}$$
$$v = \sqrt{\frac{6.67E-11 \times 5.98E24}{(6.38E6 + 250000)}}$$
$$v = 7756.338\frac{m}{s}$$

$\boxed{F_c = F_c}$; Orbit

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

; mass of object is irrelevant

Earth

$$E_p = -\frac{GMm}{r}$$
$$E_p = -\frac{6.67E-11(5.98E24)(100)}{6.38E6}$$
$$E_p = -6.25E9\,J$$

$$E_k = \frac{1}{2}mv^2$$
$$E_k = 0$$

To Change Orbit $v = \#$

Orbit

$$E_p = -\frac{GMm}{r}$$
$$E_p = -\frac{6.67E-11(5.98E24)(100)}{6.38E6 + 250000}$$
$$E_p = -6.01E9\,J$$

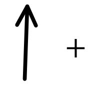
$$E_k = \frac{1}{2}mv^2$$
$$E_k = \frac{1}{2}(100)(7756.338)^2$$
$$E_k = 3.01E9\,J$$

$$E_{pi} + E_{ki} + W = E_{pf} + E_{kf}$$
$$-6.25E9 + 0 + W = -6.01E9 + 3.01E9$$
$$W = \cdots$$

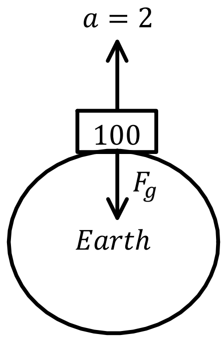
Or

$$W = \Delta E$$
$$W = \Delta E_p + \Delta E_k$$
$$W = (E_{pf} - E_{pi}) + (E_{kf} - E_{ki}) \quad \boxed{; E_{ki} = 0}$$
$$W = (-6.01E9 - (-6.25E9)) + (3.01E9 - 0)$$
$$W = 3.26E9\,J$$

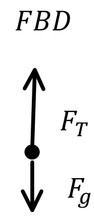
$$W = GMm\left(\frac{1}{r_i} - \frac{1}{r_f}\right) + \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i\right)$$
$$W = \frac{GMm}{2}\left(\left(\frac{2}{r_i} - \frac{2}{r_f}\right) + (v_f^2 - v_i^2)\right)$$
$$\ldots$$



P12 - 7.4 - Dyn Thrust to Accelerate Notes



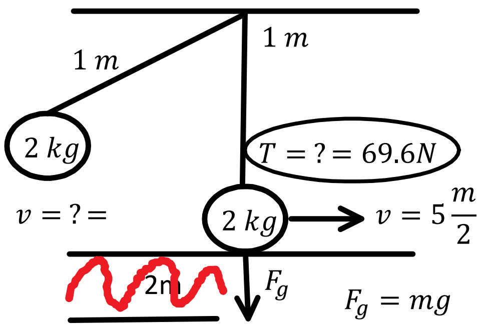
$$\Sigma F = ma$$
$$F_T - F_g = ma$$
$$F_T = ma + mg$$
$$F_T = m(a + g)$$
$$F_T = 100(2 + 9.8)$$
$$F_T = 1180\ N$$



P12 - 7.5 - Pendulum Car Flat Circle Notes

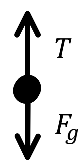
F_c : *Centripital, The sum of the forces towards the centre minus the ones away (not in FBD!)*

Find tension force at bottom.



$F_g = mg$
$F_g = 2 \times 9.8$
$F_g = 19.6\ N$

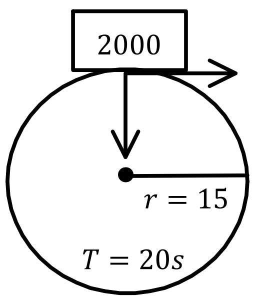
FBD



$F_c = \frac{mv^2}{r}$
$F_c = \frac{2(5)^2}{1}$
$F_c = 50\ N$

$F_c = T - F_g$
$T = F_c + F_g$
$T = 50 + 19.6$
$T = 69.6\ N$

It takes 20 s for a car of m = 2000kg to drive around a circular track with a r = 15 m. Find v of the car. Find the "a" of the car. Find the Centripetal Force on the car.



Top View

$d = 2\pi r$
$d = 2\pi(15)$
$d = 30\pi\ m$
$d = 94.25\ m$

$F_c = m\frac{4\pi^2 r}{T^2}$ **Or**
$F_c = \frac{(2000)(4)\pi^2(15)}{20^2}$
$F_c = 2960.88\ N$

$v = \frac{d}{t}$
$v = \frac{94.25}{20}$
$v = 4.71\frac{m}{s}$

$a_c = \frac{v^2}{r}$
$a_c = \frac{4.71^2}{15}$
$a_c = 1.48\frac{m}{s^2}$

$F_c = ma_c$
$F_c = (2000)(1.48)$
$F_c = 2960.88\ N$

What friction coefficient is required for the car not to slide off the track?

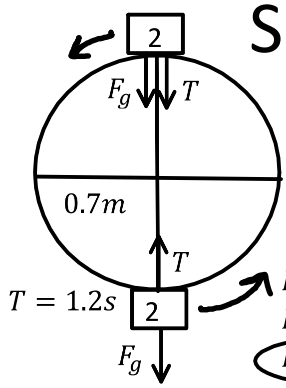
$F_c = F_f$
$ma_c = \mu mg$
$\mu = \frac{a_c}{g}$
$\mu = \frac{1.48}{9.8}$
$\mu = 0.15$

P12 - 7.6 - Ball String Circle Notes

F_g: *Straight down*
T: *Towards centre*
F_n: *Away from ground*

A 2 kg mass on a 0.7 m string is spun around a circle with a period T of 1.2 s. Find the T in the string at the top and bottom of path.

Side View



$$F_c = \frac{m4\pi^2 r}{T^2}$$

$$F_c = \frac{(2)(4)(\pi^2)(0.7)}{1.2^2}$$

$$F_c = 38.38\ N$$

$$F_g = mg$$

$$F_g = 2(9.8)$$

$$F_g = 19.6\ N$$

Top

$$F_c = T + F_g$$

$$T = F_c - F_g$$

$$T = 38.38 - 19.6$$

$$T = 18.78\ N$$

Bottom

$$F_c = T - F_g$$

$$T = F_c + F_g$$

$$T = 38.38 + 19.6$$

$$T = 57.98\ N$$

What is the minimum v of the object at the top of the circular path to remain in circular motion?

$$T = 0$$

$$F_c = T + F_g$$

$$\frac{mv^2}{r} = mg$$

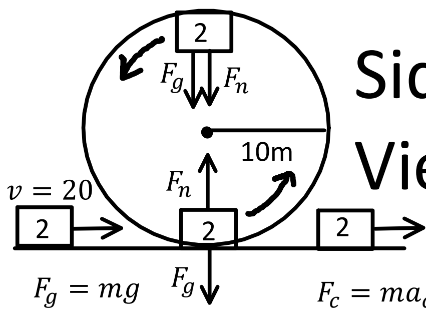
$$v = \sqrt{gr}$$

$$v = \sqrt{9.8(0.7)}$$

$$v = 2.62\frac{m}{s}$$

A 2 kg cart follows a circular path $r = 10m$ with $v = 20\frac{m}{s}$. Find F_n at the top and bottom.

Side View



$$F_g = mg$$

$$F_g = 2(9.8)$$

$$F_g = 19.6\ N$$

$$F_c = ma_c$$

$$F_c = \frac{mv^2}{r}$$

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

$$F_c = \frac{2(20)^2}{10}$$

$$F_c = 80N$$

Top

$$F_c = F_n + F_g$$

$$F_n = F_c - F_g$$

$$F_n = 80 - 19.6$$

$$F_n = 60.4N$$

Bottom

$$F_c = F_n - F_g$$

$$F_n = F_c + F_g$$

$$F_n = 80 + 19.6$$

$$F_n = 100.6N$$

What is the minimum velocity required for a cart not to fall off the circular path.

$$F_n = 0$$

$$F_c = T + F_g$$

$$F_c = F_g$$

$$\frac{mv^2}{r} = mg$$

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

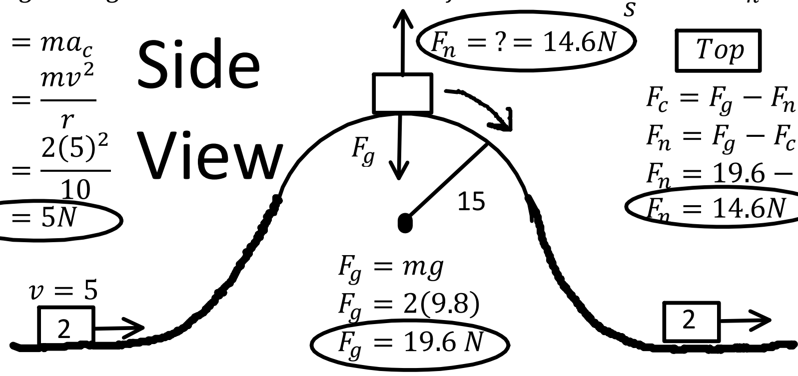
$$v = \sqrt{gr}$$

$$v = \sqrt{9.8(0.7)}$$

$$v = 2.62\frac{m}{s}$$

P12 - 7.7 - Hills Notes

A 2kg cart goes over a circular hill of $r = 15$ *at* $5\frac{m}{s}$. *Find* F_n *at top.*



$F_c = ma_c$

$F_c = \frac{mv^2}{r}$

$F_c = \frac{2(5)^2}{10}$

$F_c = 5N$

$F_g = mg$

$F_g = 2(9.8)$

$F_g = 19.6\ N$

Top

$F_c = F_g - F_n$

$F_n = F_g - F_c$

$F_n = 19.6 - 5$

$F_n = 14.6N$

Find the minimum v not to take air.

$F_c = F_g - F_n$

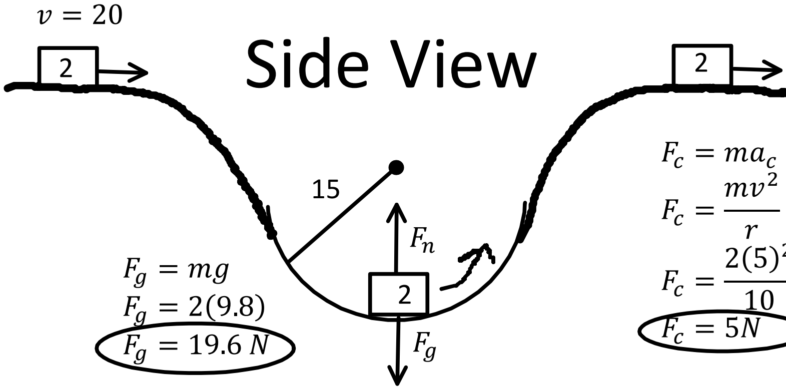
$\frac{mv^2}{r} = mg$ $F_n = 0$

$v = \sqrt{gr}$

$v = \sqrt{9.8(15)}$

$v = 12.1\frac{m}{s}$

A 2kg cart goes down a circular hill of $r = 15$ *at* $5\frac{m}{s}$. *Find* F_n *at bottom.*



$F_g = mg$

$F_g = 2(9.8)$

$F_g = 19.6\ N$

$F_c = ma_c$

$F_c = \frac{mv^2}{r}$

$F_c = \frac{2(5)^2}{10}$

$F_c = 5N$

Bottom

$F_c = F_n - F_g$

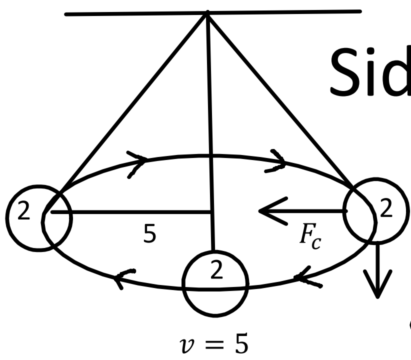
$F_n = F_c + F_g$

$F_n = 5 + 19.6$

$F_n = 24.6N$

P12 - 7.9 - Pendulum/Airplane Notes

$A\ 2kg\ ball\ travels\ 5\frac{m}{s}\ at\ in\ a\ circle\ r = 1\ m\ on\ a\ 2m\ string. Find\ T. \ldots$



Side View

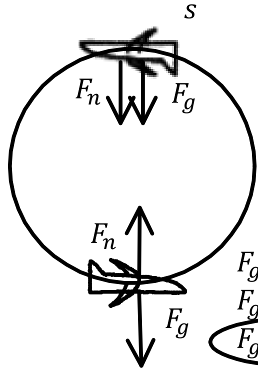
$$F_g = mg$$
$$F_g = 2(9.8)$$
$$F_g = 19.6\ N$$

$$F_c = \frac{mv^2}{r}$$
$$F_c = \frac{2(5)^2}{5}$$
$$F_c = 10N$$

$$E_{ki} + E_{pi} = E_{kf} + E_{pf}$$
$$mgh = \frac{1}{2}mv_f^2$$
$$v_f = \sqrt{2gh}$$
$$v_f = \sqrt{(2)(9.8)(0.2)}$$
$$v_f = 1.98\frac{m}{s}$$

$A\ 2kg\ model\ plane\ travels\ 20\frac{m}{s}\ at\ in\ a\ vertical\ circle\ r = 10. Find\ F_n on\ the\ pilot.$

$$F_c = ma_c$$
$$F_c = \frac{mv^2}{r}$$
$$F_c = \frac{2(20)^2}{10}$$
$$F_c = 80N$$



$$F_g = mg$$
$$F_g = 2(9.8)$$
$$F_g = 19.6\ N$$

Top

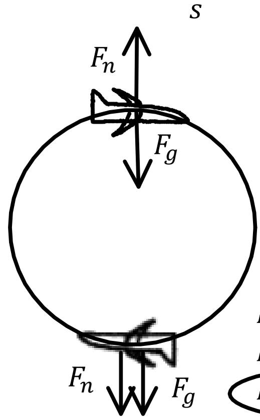
$$F_c = F_n + F_g$$
$$F_n = F_c - F_g$$
$$F_n = 80 - 19.6$$
$$F_n = 60.4N$$

Bottom

$$F_c = F_n - F_g$$
$$F_n = F_c + F_g$$
$$F_n = 80 + 19.6$$
$$F_n = 100.6N$$

$A\ 2kg\ model\ plane\ travels\ 20\frac{m}{s}\ at\ in\ a\ vertical\ circle\ r = 10. Find\ F_n on\ the\ pilot.$

$$F_c = ma_c$$
$$F_c = \frac{mv^2}{r}$$
$$F_c = \frac{2(20)^2}{10}$$
$$F_c = 80N$$



Top

$$F_c = F_g - F_n$$
$$F_n = F_g - F_c$$
$$F_n = 19.6 - 80$$
$$F_n = -60.4N$$

How strong must the seat belt be?

$$F_g = mg$$
$$F_g = 2(9.8)$$
$$F_g = 19.6\ N$$

Bottom

$$F_c = -F_n - F_g$$
$$F_n = -F_c - F_g$$
$$F_n = -80 - 19.6$$
$$F_n = -99.6N$$

$> 99.6N$