CIRCULAR MOTION.

① a) $\Sigma \vec{F} = ma$

$$\frac{G M_e \cancel{m_s}}{r^{\cancel{2}}} = \frac{\cancel{m_s} V_s^2}{\cancel{r}}$$

$$V_s = \sqrt{\frac{G M_e}{r}}$$

$$V_s = \sqrt{\frac{G M_e}{(r_e + H)}}$$

$$V_s = 7785$$

$$\boxed{V_s = 7.79 \times 10^3 \, m/s}$$

b) ☑ **Less** than in the lower orbit.

c) Since: $V_s = \sqrt{\frac{GM}{(r_e + H)}}$

$$H\uparrow \Rightarrow V\downarrow$$

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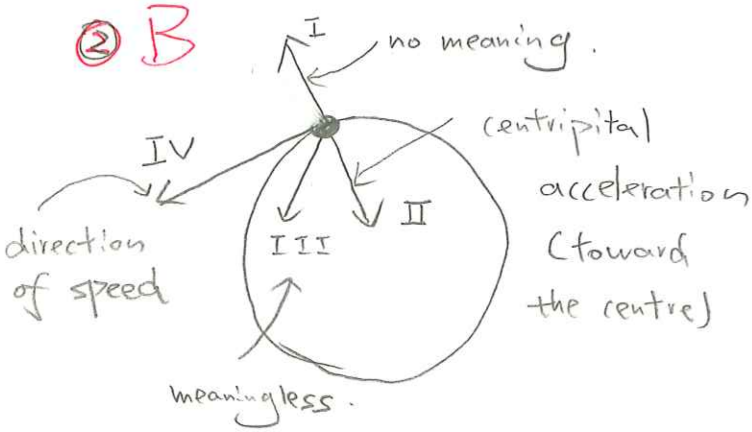
② B



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③ C

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

$$= \frac{8^2}{5}$$

$$= 12.8 \, m/s$$

$$= 13 \, m/s$$

④ C

$$\Sigma F = F_g = \frac{G M_s M_e}{d^2} = M_s a$$

$$a = \frac{G M_E}{d^2}$$

$$a = \frac{6.67 \times 10^{-11} \times 1.99 \times 10^{30}}{(1.50 \times 10^{11})^2}$$

$$= 0.005899 \, m/s^2$$

$$= 5.9 \times 10^{-3} \, m/s^2$$

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⑤ $\Sigma F = ma$

a) $\Sigma F = \frac{m 4 \pi^2 r}{T^2}$

$$= \frac{35 \times 4 \times \pi^2 \times 12}{9^2}$$

$$= 204.7 \, N$$

$$\Sigma F = F_g - F_N$$

$$F_N = F_g - \Sigma F$$

$$= 35 \times 9.8 - 204.7$$

$$= 138.3 \, N$$

$$\boxed{= 1.4 \times 10^2 \, N}$$

b) **iii The same** as at the bottom.

$\because a_c = \frac{4 \pi^2 r}{T^2}$

All 4, π, r, T are constant

Ac doesn't change.

☆ 6

$\cancel{E_{ki}}^{0} + E_{pi} = E_{kf} + \cancel{E_{pf}}^{0}$

$mgh = \frac{1}{2} m v_f^2$

$v_f^2 = 2gh$

$v_f^2 = 2g(3.1\,m)$

$\sum \vec{F} = F_g + F_N$

$(1.3 \times g_p + 21) = \frac{mv^2}{r}$

$(1.3 \times g_p + 21) = \frac{1.3 \times 2g(4.5 - 1.4)}{1.4/2}$

$1.3 g_p + 21 = \frac{2.6 \times 3.1 \times g}{0.7}$

$21 = 10.21 g_p$

$g_p = 2.06\,m/s^2$

$\boxed{g_p = 2.1\,m/s^2}$

9. B $\sum \vec{F} = m\vec{a}$

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

$v = \sqrt{\frac{GM}{r}}$

$\Rightarrow v \propto \frac{1}{\sqrt{r}} \Rightarrow v_2 = \frac{1}{\sqrt{2}} v_1$

$v_2 = 5700\,m/s$

OR

$\sum \vec{F} = m\vec{a} \Rightarrow \frac{GMm}{r^2} = \frac{mv^2}{r}$

$\Rightarrow v^2 r = GM$

$v_1^2 r_1 = v_2^2 r_2 = v_2^2 (2r_1)$

$v_1^2 r_1 = v_2^2 (2r_1)$

$\Rightarrow v_2^2 = \frac{v_1^2}{2} \Rightarrow v_2 = \sqrt{\frac{8000^2}{2}}$

(b) $v_2 = \frac{8000\,m/s}{\sqrt{2}} = 5700\,m/s$

7. A $\sum \vec{F} = m\vec{a}$

$F_N^* + mg = \frac{mv^2}{2}$

*F_N is force from bucket on water.

For v_{min} F_N is ZERO....

$\cancel{F_N}^0 + mg = \frac{mv^2}{r}$

$v_c = \sqrt{gr}$

$v_c = \sqrt{1.3 \times 9.8}$

$\boxed{v_c = 3.6\,m/s}$

8. C $\sum \vec{F} = m\vec{a}$

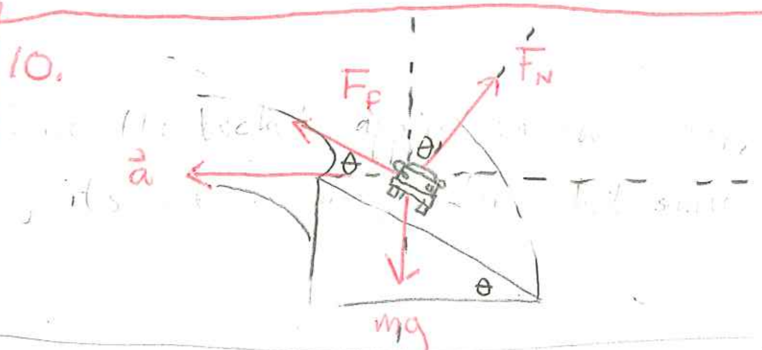
$\frac{GMm}{r^2} = \frac{mv^2}{r}$

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

$= 4.15 \times 10^7\,m$

$\boxed{= 4.2 \times 10^7\,m}$

10.



No tilt. Need both F_N and F_f to solve, so no advantage to tilting ⇒ line up axes with $\vec{a}$.

$\sum \vec{F}_y = 0$

$F_N \cos\theta + F_f \sin\theta = mg$

$F_N \cos\theta + \mu F_N \sin\theta = mg$

$F_N = \frac{mg}{(\cos\theta + \mu \sin\theta)}$

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

$F_f \cos\theta - F_N \sin\theta = \frac{mv^2}{r}$

$\mu F_N \cos\theta - F_N \sin\theta = \frac{mv^2}{r}$

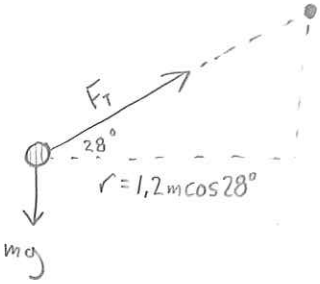
$F_N(\mu\cos\theta - \sin\theta) = \frac{mv^2}{r}$

substitute

$\frac{mg(\mu\cos\theta - \sin\theta)}{(\cos\theta + \mu\sin\theta)} = \frac{mv^2}{r}$

$v = 19.736....$ $\Rightarrow \boxed{2.0 \times 10\,m/s}$

(11)



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

$F_T \cos 28° = \frac{m 4\pi^2 r}{T^2}$

$F_T \cancel{\cos 28°} = \frac{m 4\pi^2 L \cancel{\cos 28°}}{T^2}$

2 unknowns, m and T.
GO TO $\hat{y}$!

$\sum \vec{F}_y = 0$

$F_T \sin 28° = mg$

$m = \frac{F_T \sin 28°}{g} = 0.766484184 \text{ kg}$

$T = \sqrt{\frac{m 4\pi^2 (1.2\text{m})}{F_T}} = \boxed{1.5 \text{ s}}$

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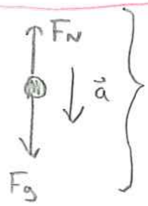
(12)



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

$F_g - F_N = \frac{mv^2}{r}$

$r = \frac{mv^2}{F_g - F_N} = 80\text{m} \Rightarrow \boxed{8.0 \times 10 \text{ m}}$

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(13)

$a = \frac{v^2}{r} \Rightarrow r = \frac{v^2}{a} = 1763.\overline{3}\text{ m} \Rightarrow \boxed{1.8 \text{ km}}$

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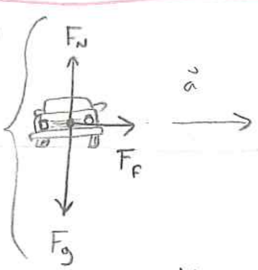
(14)

$\sum \vec{F}_y = 0$

$F_N = mg$



$\sum \vec{F}_x = ma$

$\mu F_N = \frac{m v_{max}^2}{r}$

$\mu \cancel{m} g = \frac{\cancel{m} v_{max}^2}{r}$

$v_{max} = \sqrt{\mu g r}$

$\boxed{v_{max} = 19.9 \text{ m/s}}$

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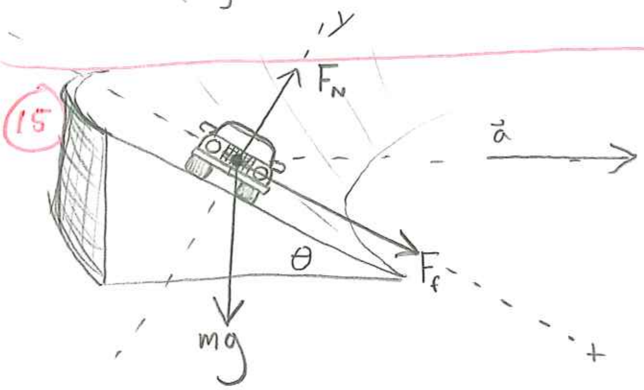
(15)



TILT AXES!

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

$F_f + mg \sin\theta = m\frac{v^2}{r}\cos\theta$

$v = \sqrt{\frac{r(F_f + mg\sin\theta)}{m\cos\theta}} = \boxed{15 \text{ m/s}}$

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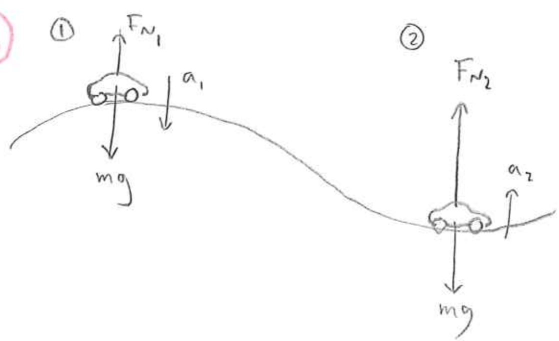
(16)



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

$\sum F = \frac{mv^2}{r}$

$\sum F_1 = \sum F_2$

① $\sum F_1 = mg - F_{N_1}$

$\sum F_1 = 2000\text{N} = \sum F_2$

② $\sum F = F_{N2} - mg$

$F_{N2} = \sum F + mg$

$= 13760\text{N}$

$\boxed{\vec{F}_{N2} = 14\,000 \text{ N}}$