Year 12 Physics	TEST # 2 – Gravity & Motion II	2022

NAME: SOLUTIONS

Total Marks: 36 *Time Allowed: 45 minutes*

(Formula sheet and scientific calculator permitted)

Question 1 **(7 marks)**

(a) Explain why communications satellites are always placed at the same height above the Earth's surface. [3]

These satellites must have a fixed orbital period of 24 hours in order to stay in the same position relative to a point on the Earth's surface ✓

By Kepler's 3rd Law, $r^3 \propto T^2$. ✓
Since T is fixed (24 hours), r must be fixed, & hence the height above the Earth's surface ($= r - r_E$) is fixed. ✓

3

(b) What is the acceleration of a communications satellite travelling at 3.07×10^3 ms^{-1} at a height of 35 790 km? [4]

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

$$= \frac{(3.07 \times 10^3)^2}{(35790 + 6370) \times 1000}$$ ✓ ✓

$$\approx \underline{0.224 \text{ ms}^{-2}}$$ ✓

towards centre of Earth ✓

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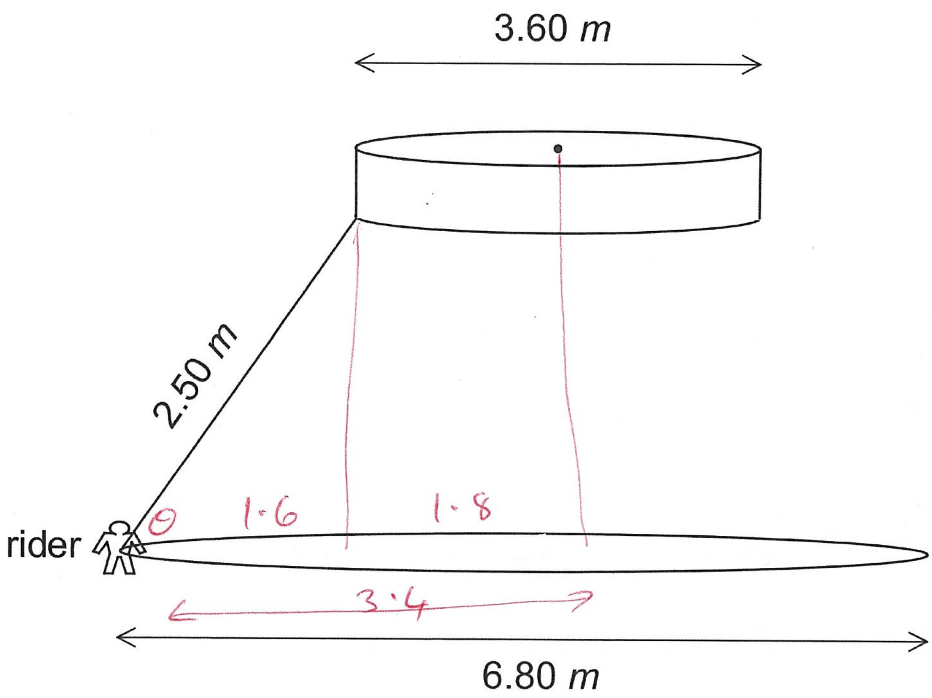
Question 2 **(7 marks)**

The chair-o-plane is a fairground ride in which riders undergo a circular path on the end of a chain attached to their seats.



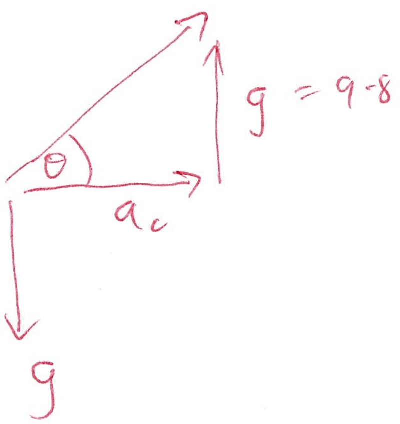
The diagram shows a rider (and seat) of mass 36.0 kg on the end of a 2.50 m chain.

The top of the chain is attached to a rotating disc of diameter 3.60 m, and the rider travels in a horizontal circle of diameter 6.80 m.

Determine:

(a) the magnitude of the rider's acceleration, [4]

$\cos\theta = \frac{1.6}{2.5}$ ✓ $\Rightarrow \theta \simeq 50.208°$ ✓



$\tan\theta = \frac{9.8}{a_c}$ ✓

$\therefore a_c \simeq \frac{9.8}{\tan\theta} \simeq \underline{8.16 ms^{-2}}$ ✓

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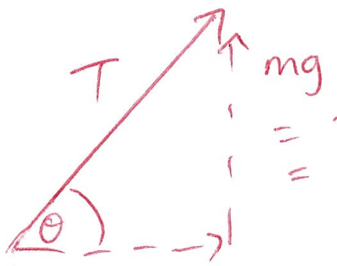
(b) the magnitude of the tension in the chain. [3]



$= 36 \times 9.8$
$= 352.8\text{N}$

$$\sin\theta = \frac{352.8}{T}$$

$$\therefore T = \frac{352.8}{\sin\theta}$$

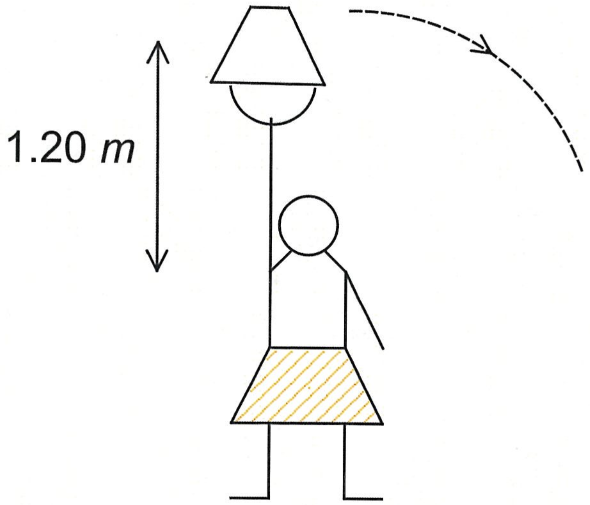
$$\approx \underline{459\text{ N}}$$

3

3

Question 3 **(9 marks)**

Harriet whirls a bucket of water in a vertical circle of radius 1.20 m, as shown (the radius being measured to the centre of mass of the bucket of water). The mass of the bucket and water is 3.00 kg.



(a) What will be the tension in Harriet's arm when the bucket is at its highest point, if the frequency of the rotation is 1.00 Hz? [5]

$$v = 2\pi r f$$
$$= 2\pi \times 1.2 \times 1$$
$$\simeq 7.540\ ms^{-1}$$ ✓

$$\therefore F_{res} = \frac{mv^2}{r} = \frac{3 \times 7.540^2}{1.2}$$ ✓

$$\simeq 142\ N$$ ✓

−

+

$$F_{res} = T + Wt$$
$$142 = T + 3 \times 9.8$$ ✓

$$\therefore T \simeq \underline{113N}$$ ✓

5

5

(b) What is the minimum frequency required to stop the water falling out of the bucket? [4]

$T = 0 \Rightarrow F_{res} = wt$

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

$\therefore v^2 = rg$

$v^2 = 1.2 \times 9.8$

$v \simeq 3.429 \text{ ms}^{-1}$

$2\pi r f = 3.429$

$f = \frac{3.429}{2\pi \times 1.2}$

$\simeq \underline{0.455 \text{ Hz}}$

4

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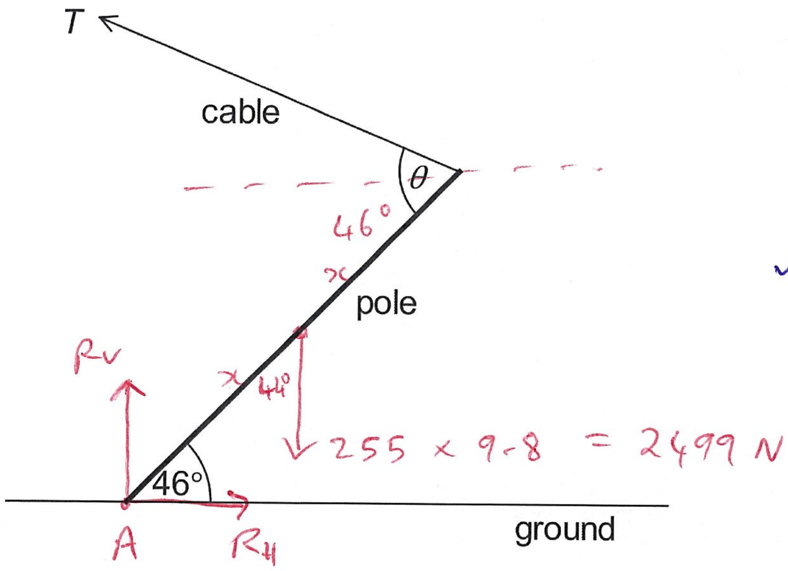
Question 4 **(13 marks)**

The diagram shows a 255 kg uniform concrete pole being lifted upright by means of a force (T) applied via a cable. Assume that the reaction force of the ground is able to hold the bottom of the pole still.



(a) What is the tension (T) in the cable when $\theta = 75.0°$? [4]

about A,

$$\Sigma CM = \Sigma AM$$

$$2499 \times \sin 44° = 2x\, T \sin 75°$$

$$\therefore T = \underline{899 \text{ N}}$$

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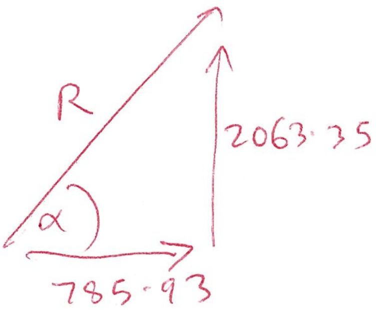
(b) What is the reaction force on the bottom of the pole when $\theta = 75.0°$? [6]

$\Sigma F_H = 0 \Rightarrow R_H = T\cos 29°$

$\simeq 785.93$ N

$\Sigma F_V = 0 \Rightarrow R_V + T\sin 29° = 2499$

$\therefore R_V \simeq 2063.35$ N



$\therefore R = \sqrt{785.93^2 + 2063.35^2}$

$\simeq 2207$ N

6

$\alpha = \tan^{-1} \dfrac{2063.35}{785.93} \simeq 69.1°$

i.e. Reaction is $\underline{2.21 \times 10^3 \text{ N}}$ at $\underline{69.1° \text{ above hor.}}$

(c) What value of θ is least likely to cause the cable to break when the pole is in the position shown? Why? [3]

$\theta = 90°$.

This maximizes the anti c/w moment of the T force since $\sin\theta$ is then 1.

Hence, a smaller T force is needed to balance the c/w moment.

3

- End of Questions -

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