KEY

First Name:______________________ Last Name:______________________

Phys20 – Circular Motion - REVIEW

/25 marks

Unit2 – Dynamics

$\vec{F}_{net} = m\vec{a}$ $\vec{F}_g = m\vec{g}$ $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots$ $F_{f\,static} \leq \mu_s F_N$ $F_{f\,kinetic} = \mu_k F_N$

$F_g = \frac{G m_A m_B}{r^2}$ $g = \frac{G M_{source}}{r^2}$ $where\ G = 6.67x10^{-11}\ \frac{Nm^2}{kg^2}$

Unit3 – Circular Motion, Work, and Energy

$T = \frac{1}{f}$ $f = \frac{1}{T}$ $v = \frac{2\pi r}{T}$ $v = 2\pi r f$ $a_c = \frac{v^2}{r}$ $F_c = \frac{mv^2}{r}$

Your questions will be marked as follows, unless otherwise specified:

1 Mark Question

- 1 mark – Answer

3 Mark Question

- 1 mark – "What you know"
- 1 mark – Equation with units substituted in
- 1 mark - Answer

KEY

Unit3 – Circular Motion, Work, and Energy

$T = \frac{1}{f}$ $f = \frac{1}{T}$ $v = \frac{2\pi r}{T}$ $v = 2\pi r f$ $a_c = \frac{v^2}{r}$ $F_c = \frac{mv^2}{r}$

1

Q1: A ball spins in a tight loop with a frequency of 15.6 Hz. What is the Period of rotation? *(1 mark)*

$T = 6.41 \times 10^{-2}$ s

or

$T = 0.0641$ s

3

Q2: A ball is attached to a 3m wire and swings at 15m/s. What is the frequency of rotation? *(3 marks)*

$r = 3$ m
$v = 15$ m/s
$f = ?$

$v = 2\pi r f$
$(15\text{ m/s}) = 2\pi(3\text{ m})f$

$f = 0.796$ Hz

3

Q3: If a car is rounding a 10m radius corner at a steady 8m/s, what is the centripetal acceleration of the car? *(3 marks)*

$r = 10$ m
$v = 8$ m/s
$a_c = ?$

$a_c = \frac{v^2}{r}$
$= \frac{(8\text{ m/s})^2}{10\text{ m}}$

$a_c = 6.4\text{ m/s}^2$

REMINDER: *Have you included your units with your answer?*

KEY

$F_g = \frac{G m_A m_B}{r^2}$	$g = \frac{G M_{source}}{r^2}$	where $G = 6.67x10^{-11} \frac{Nm^2}{kg^2}$

Unit3 – Circular Motion, Work, and Energy

$T = \frac{1}{f}$ $f = \frac{1}{T}$ $v = \frac{2\pi r}{T}$ $v = 2\pi r f$ $a_c = \frac{v^2}{r}$ $F_c = \frac{mv^2}{r}$

4

Q4: The Moon orbits the Earth ($5.97x10^{24}$ kg). If the distance between the center of masses is $3.8440x10^8$ m, how fast (m/s) does the Moon actually move? *(4 marks)*

$m_{Moon} = 7.348 \times 10^{22}$ kg

1 mark – "What you know"
1 mark – Force of Gravity
1 mark – Centripetal Force
1 mark – Answer

OR

1 mark – Equation setup
1 mark – Simplify equation
1 mark – Equation with units
1 mark - Answer

$m_E = 5.97 \times 10^{24}$ kg
$m_M = 7.348 \times 10^{22}$ kg
$r = 3.8440 \times 10^8$ m

$F_g = \frac{G m_1 m_2}{r^2} = 1.980 \times 10^{20}$ N

$F_g = 1.980 \times 10^{20}$ N

$F_c = 1.980 \times 10^{20}$ N

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

$V = \sqrt{\frac{F_c r}{m}}$

$V = 1017.79$ m/s

$F_c = F_g$

$\frac{mv^2}{r} = \frac{G M_{source} m_{Moon}}{r^2}$

$V^2 = \frac{G M_{Earth}}{r}$

$V = \sqrt{\frac{G M_{Earth}}{r}}$

Will allow variations

$V = \sqrt{\frac{(6.67 \times 10^{-11} \frac{Nm^2}{kg^2})(5.97 \times 10^{24})}{3.844 \times 10^8 m}}$

$V = 1017.79$ m/s

***REMINDER:** Have you included your units with your answer?*

KEY

Unit 3 – Circular Motion, Work, and Energy

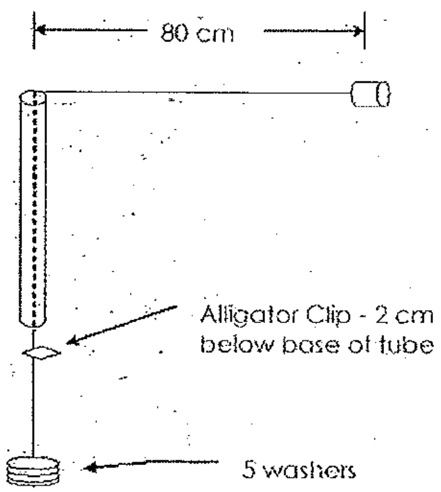
$T = \frac{1}{f}$ $f = \frac{1}{T}$ $v = \frac{2\pi r}{T}$ $v = 2\pi r f$ $a_c = \frac{v^2}{r}$ $F_c = \frac{mv^2}{r}$

1kg = 1000g 1m = 100cm

/4

Q5: A rubber stopper of mass 15g is attached to a string and swung in a circle. If the stopper moves with a speed of 5m/s and a radius of 80cm, what is the mass of the hanging washers at the bottom of the string?

1 mark – "What you know" in S.I. Units
1 mark – Centripetal Force
1 mark – Tension and Gravitational Force
1 mark – Mass of hanging washers



$m = 0.015\,kg$
$v = 5\,m/s$
$r = 0.8\,m$

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

$= \frac{(0.015kg)(5\,m/s)^2}{(0.8m)}$

$F_c = 0.46875\,N$

$F_T = 0.46875N$
$F_{G_{washers}} = 0.46875N$

$F_g = mg$
$(0.46875N) = m(9.81\,m/s^2)$

$m = 4.78 \times 10^{-2}\,kg$
or
$m = 0.0478\,kg$
or
$m = 47.8g$

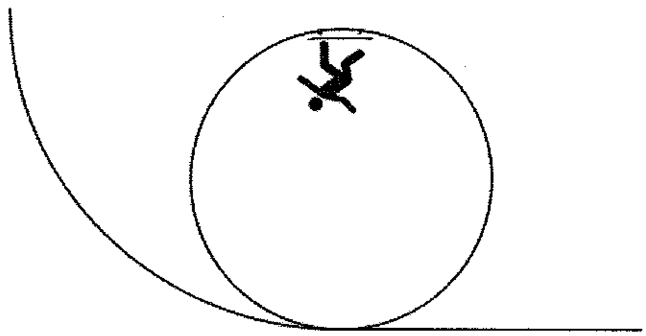
***REMINDER:** Have you included your units with your answer?*

KEY

Use the following information to answer Q6-8.

A skateboarder of mass 50kg wants to skate through a loop of diameter 4m.

radius = 2m



/3 **Q6:** What is the minimum speed the skateboarder needs to complete this loop? *(3 marks)*

$m = 50kg$

$r = 2m$

$F_c = F_g$

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

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

$\frac{v^2}{(2m)} = (9.81 m/s^2)$

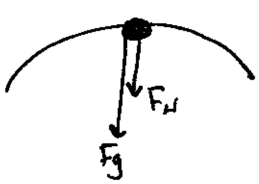
$v = 4.43 m/s$

/3 **Q7:** If the skateboarder was travelling at 7m/s, what is the normal force they experience at the top of the loop? *(3 marks)*

$m = 50kg$

$r = 2m$

$v = 7 m/s$



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

$= \frac{(50kg)(7m/s)^2}{(2m)}$

$F_c = 1225N$ [down]

$F_g = mg$

$= (50kg)(9.81 m/s^2)$

$F_g = 490.5N$ [down]

$F_c = F_g + F_N$

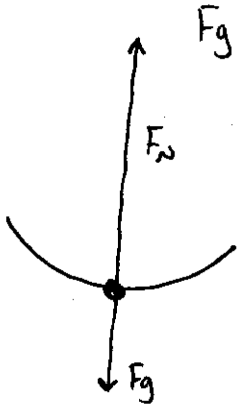
$1225N$ [down] $= 490.5N$ [down] $+ F_N$

$F_N = 734.5N$ [down]

/1 **Q8:** If the skateboarder was travelling at 7m/s, what is the normal force they experience at the bottom of the loop? *(1 mark)*

$F_c = 1225N$ [up]

$F_g = 490.5N$ [down]



$F_c = F_g + F_N$

$1225N = -490.5N + F_N$

$F_N = 1715.5N$ [up]

KEY

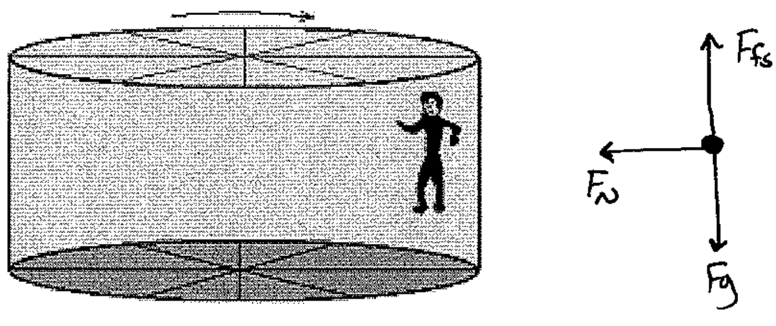
/3

Q9: The diagram is a schematic of a ride at the Calgary Stampede. In this ride, the force of friction supports the passengers on the vertical walls of a spinning cage. The coefficient of friction between the wall and the passengers is 0.320. The cage has a diameter of 13.4m. What is the maximum period that the cage could have so that the passengers would not slide down the wall? *(3 marks)* T

Sketch of a rider held against the inside wall of a rotating cylinder. Diagram is not to scale.

$r = 6.7\,m$

$\mu_s = 0.320$



First... ① F_N acts as our centripetal force. $F_c = F_N = \frac{mv^2}{r}$

② F_{fs} balances out F_g ($F_{net_y} = 0\,N$) so $|F_{fs}| = |F_g| = mg$

Option #1: Super Equation!

$F_{fs} = \mu_s F_N$

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

Masses cancel.

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

Doing some math.

$v^2 = \frac{gr}{\mu_s}$

$v = \sqrt{\frac{gr}{\mu_s}} = \sqrt{\frac{(9.81\,m/s^2)(6.7\,m)}{0.320}}$

$v = 14.33\,m/s$

Where $v = \frac{2\pi r}{T}$

or $T = \frac{2\pi r}{v} = \frac{2\pi(6.7\,m)}{(14.33\,m/s)}$

$\boxed{T = 2.938\,s}$

Option #2: Mass shouldn't matter (or else it would have been given), so why not just make one up? After all, this should work for ALL masses.

Assume $m = 1\,kg$

$F_g = mg = (1\,kg)(9.81\,m/s^2) = 9.81\,N\,[down]$

$F_{fs} = 9.81\,N\,[up]$ since $F_{net_y} = 0\,N$

$F_{fs} = \mu_s F_N$

$9.81\,N = (0.320)\,F_N$

$F_N = 30.65625\,N$

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

$30.65625\,N = \frac{(1\,kg)v^2}{(6.7\,m)}$

$v = 14.33\,m/s$

Where $v = \frac{2\pi r}{T}$ $\quad 14.33\,m/s = \frac{2\pi(6.7\,m)}{T}$

$\boxed{T = 2.938\,s}$