TYPICAL NUMERIC QUESTIONS FOR PHYSICS I REGULAR

QUESTIONS TAKEN FROM CUTNELL AND JOHNSON

CIRCULAR MOTION

CONTENT STANDARD IB

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

$F_c = ma_c = \frac{mv_t^2}{r}$

1. A car traveling at 20 m/s rounds a curve so that its centripetal acceleration is 5 m/s^2. What is the radius of the curve?
   A) 4 m B) 8 m C) 80 m D) 160 m E) 640 m

$r = \frac{20^2}{5}$

2. A satellite is placed in a circular orbit to observe the surface of Mars from an altitude of 144 km. The equatorial radius of Mars is 3397 km. If the speed of the satellite is 3480 m/s, what is the magnitude of the centripetal acceleration of the satellite?
   A) 2.17 m/s^2 B) 2.60 m/s^2 C) 2.99 m/s^2 D) 3.42 m/s^2 E) 4.05 m/s^2

$a_c = \frac{(3480)^2}{(3397+144)\times 1000}$ ↑ km to m

Use the following to answer questions 3-4:

The world's largest Ferris wheel with a radius of 50.0 m is located in Yokohama City, Japan. Each of the sixty gondolas on the wheel takes 1.00 minute to complete one revolution when it is running at full speed. **Note**: Ignore gravitational effects.

$v = \frac{2\pi r}{T} = \frac{2\pi 50m}{60s} = 5.24 \frac{m}{s}$

3. What is the uniform speed of a gondola when the Ferris wheel is running at full speed?
   A) 314 m/s B) 1.67 m/s C) 10.5 m/s D) 18.6 m/s E) 5.24 m/s

4. What is the centripetal acceleration of the gondola when the Ferris wheel is running at full speed?
   A) 0.548 m/s^2 B) 6.91 m/s^2 C) 2.21 m/s^2 D) 0.732 m/s^2 E) 6.28 m/s^2

$a_c = \frac{(5.24)^2}{50}$

5. A certain string just breaks when it is under 400 N of tension. A boy uses this string to whirl a 10-kg stone in a horizontal circle of radius 10 m. The boy continuously increases the speed of the stone. At approximately what speed will the string break?
   A) 10 m/s B) 20 m/s C) 80 m/s D) 100 m/s E) 400 m/s

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

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

$v_t = \sqrt{\frac{400 \cdot 10}{10}}$

6. A car enters a horizontal, curved roadbed of radius 50 m. The coefficient of static friction between the tires and the roadbed is 0.20. What is the maximum speed with which the car can safely negotiate the unbanked curve?

A) 5 m/s B) 10 m/s C) 20 m/s D) 40 m/s E) 100 m/s

$F_f = F_c$

$\mu mg = \frac{mv_t^2}{r}$

$0.2(9.8) = \frac{v_t^2}{50}$

Use the following to answer questions 7-9:

A 1000-kg car travels along a straight 500-m portion of highway (from **A** to **B**) at a constant speed of 10 m/s. At **B**, the car encounters an unbanked curve of radius 50 m. The car follows the road from **B** to **C** traveling at a constant speed of 10 m/s while the direction of the car changes from east to south.

7. What is the magnitude of the acceleration of the car as it travels from A to B?

A) 2 m/s^2 B) 5 m/s^2 C) 10 m/s^2 D) 20 m/s^2 E) zero m/s^2

8. What is the magnitude of the acceleration of the car as it travels from B to C?

A) 2 m/s^2 B) 5 m/s^2 C) 10 m/s^2 D) 20 m/s^2 E) zero m/s^2

$a_c = \frac{v_t^2}{r} = \frac{10^2}{50}$

9. What is the magnitude of the frictional force between the tires and the road as the car negotiates the curve from B to C?

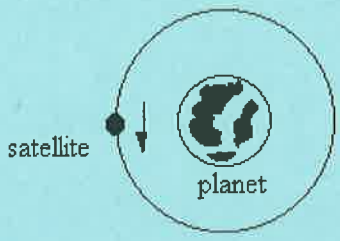
A) 20 000 N B) 10 000 N C) 5000 N D) 2000 N E) 1000 N

$F_g = F_c = \frac{mv_t^2}{r}$

$F_g = F_c = \frac{1000(10)}{50}$

Use the following to answer question 10:

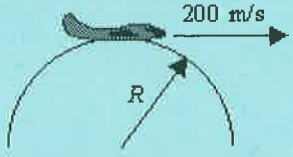
A 2400-kg satellite is in a circular orbit around a planet. The satellite travels with a constant speed of 6.67×10^3 m/s.
The radius of the circular orbit is 8.92×10^6 m.



$a_c = \frac{v_t^2}{r} = \frac{(6.67 \times 10^3)^2}{8.92 \times 10^6}$

10. What is the acceleration of the satellite?
A) 2.5 m/s^2 B) 21 m/s^2 C) 9.8 m/s^2 D) 5.0 m/s^2 E) zero m/s^2

11. A plane is traveling at 200 m/s following the arc of a vertical circle of radius R. At the top of its path, the passengers experience "weightlessness." To one significant figure, what is the value of R?



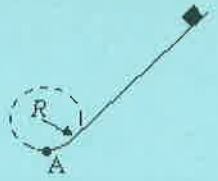
$g = a_c = \frac{v_t^2}{r}$

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

$9.8 = \frac{(200)^2}{r}$

A) 200 m B) 1000 m C) 2000 m D) 4000 m E) 40 000 m

12. A 25-kg box is sliding down an ice-covered hill. When it reaches point A, the box is moving at 11 m/s. Point A is at the bottom of a circular arc that has a radius $R = 7.5$ m. What is the magnitude of the normal force on the box at Point A?



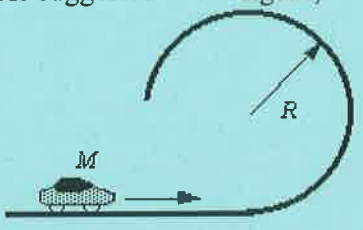
$F_N = F_C = \frac{m v_t^2}{r}$

$F_N = F_C = \frac{25(11)^2}{7.5}$

A) 250 N B) 280 N C) 400 N D) 650 N E) 900 N

Use the following to answer question 13:

A small car of mass M travels along a straight, horizontal track.
As suggested in the figure, the track then bends into a vertical circle of radius R.



13. What is the minimum acceleration that the car must have at the top of the track if it is to remain in contact with the track?
A) 4.9 m/s^2, downward
B) 4.9 m/s^2, upward
C) 9.8 m/s^2, upward
D) 9.8 m/s^2, downward
E) 19.6 m/s^2, upward

Use the following to answer questions 14-16:

A 1500-kg car travels at a constant speed of 22 m/s around a circular track that has a radius of 85 m.

14. Which statement is true concerning this car?
A) The velocity of the car is changing.
B) The car is characterized by constant velocity.
C) The car is characterized by constant acceleration.
D) The car has a velocity vector that points along the radius of the circle.
E) The car has an acceleration vector that is tangent to the circle at all times.

15. What is the magnitude of the acceleration of the car?
A) 5.7 m/s^2 B) 0.26 m/s^2 C) 9.8 m/s^2 D) 1.2 m/s^2 E) zero m/s^2

16. Determine the magnitude of the net force that acts on the car.
A) 390 N B) 1800 N C) 8.5×10^3 N D) 1.5×10^4 N E) zero newtons

Use the following to answer questions 17-18:

A rocket orbits a planet in a circular orbit at a constant speed as shown in the drawing.
Note the arrows shown:

17. At the instant shown in the drawing, which arrow indicates the direction of the acceleration of the rocket?
A) 1 B) 2 C) 3 D) 4 E) 5

18. At the instant shown in the drawing, which arrow shows the reaction force exerted on the planet by the rocket?
A) 1 B) 2 C) 3 D) 4 E) 5

$v_t = \frac{2\pi r}{T}$

Use the following to answer question 19:

An airplane flying at 115 m/s due east makes a gradual turn following a circular path to fly south. The turn takes 15 seconds to complete.

$\omega = \frac{(2\pi/2)}{15}$ $a_c = \frac{v_t^2}{r}$

$\omega = v_t r$

$a_c = \frac{4\pi^2 \omega}{T v_t}$

Extra hard

19. What is the magnitude of the centripetal acceleration during the turn?
A) zero m/s^2 B) 6.9 m/s^2 C) 8.1 m/s^2 D) 9.8 m/s^2 E) 12 m/s^2

$0.0024\ m/s^2$

20. A ball moves with a constant speed of 4 m/s around a circle of radius 0.25 m. What is the period of the motion?
A) 0.1 s B) 0.4 s C) 0.7 s D) 1 s E) 2 s

Hard

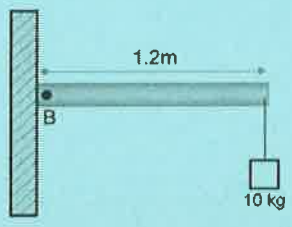
$C = \pi d = 2\pi r$
$= 2\pi 0.25$
$C = 1.57\ m$

$4 = \frac{1.57}{t}$

PRACTICE 112m = 4 sec 5.4

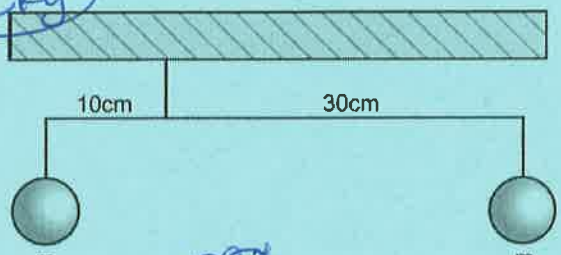
PRACTICE

1. A 10-kilogram mass is suspended from the end of a beam that is 1.2 meters long. The beam is attached to a wall. Find the magnitude and direction (clockwise or counterclockwise) of the resulting torque at point B. Hint: Remember that force is measured in newtons, not kilograms.



$\tau = Fr = mgr$ $10(9.8)1.2 = 117.6\ Nm$

2. Two masses m_1 and m_2 are suspended on an ornament. The ornament is hung from the ceiling at a point which is 10 centimeters from mass m_1 and 30 centimeters from mass m_2.



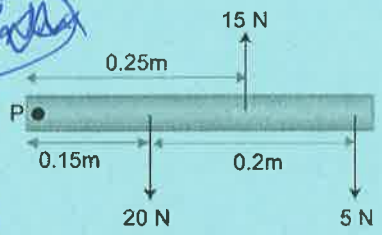
   a. If $m_1 = 6$ kg, what does m_2 have to be for the ornament to be in rotational equilibrium? 2 kg $m_1 g r_1 = m_2 g r_2$

   b. Calculate the ratio of $\frac{m_1}{m_2}$ so that the ornament will be horizontal. 3/1

   c. Suppose $m_1 = 10$ kg and $m_2 = 2$ kg. You wish to place a third mass, $m_3 = 5$ kg, on the ornament to make it balance. Should m_3 be placed to the right or to the left of the ornament's suspension point? Explain your answer. Right — to make Torque Balance more CW Torque is Needed

   d. Calculate the exact location where m_3 should be placed. 8cm Right

3. Forces are applied on the beam as shown on the figure at right.



   a. Find the torque about point P produced by each of the three forces.

   b. Find the net torque about point P. −1 Nm

   c. A fourth force is applied to the beam at a distance of 0.30 m to the right of point P. What must the magnitude and direction of this force be to make the beam in rotational equilibrium? 3.33 N

Force	Torque@P
20	−3 Nm
15	+3.75 Nm
5	−1.75 Nm

Rotational and Circular Motion – Sample Essay Questions

1) Does every point on the spoke of a moving bicycle with constant velocity move at the same angular speed? The same tangential speed? Explain your answers.

Yes

Same Rate of change in angle

NO

$v_t = \omega r$

Radius length matters ∴ Further from axle is faster

2) Why is the rate at which a point on a circle changes its angle called angular **speed** and not angular **velocity**?

Implies that a direction is a part of it (and it is not)

Not described as a vector

3) A roller coaster engineer realizes that the model of a new coaster has a loop that puts the passengers in danger because the car sometimes does not make it over the loop. What should be done to the design of the loop to give more centripetal force keeping it moving in a circle?

$$F_c = \frac{m V_t^2}{r}$$

- Faster speed in the loop

- smaller turning Radius

Less Practical: more mass in train

4) Is it necessary to test a new roller coaster with a loop at Cedar Point with mannequins in the seats to simulate the coaster being full? Explain why or why not using centripetal equations.

$$F_c = \frac{m V_t^2}{r}$$

Centripetal force is mass dependent

(Also to see if the stress damages the Roller Coaster)

Physics Name _____

Period _____

Torque Worksheet

1. a. Calculate the torque produced by a 75-N perpendicular force at the end of a 0.2-m long wrench.

$\tau = F r$

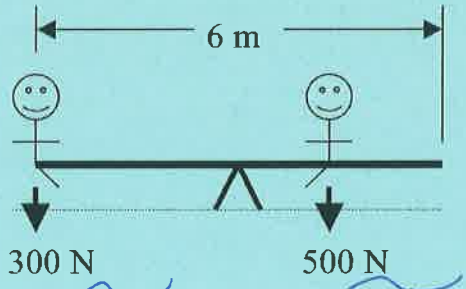
$= 75(0.2) = 15\ Nm$

b. Calculate the torque produced by the same 75-N force when a pipe extends the length of the wrench to 0.5 m.

$\tau = F r$

$75(0.5) = 37.5\ Nm$

2. Two children are sitting on a see-saw, as shown. Calculate the distance the 500-N child should sit from the fulcrum (pivot) to balance the see-saw.



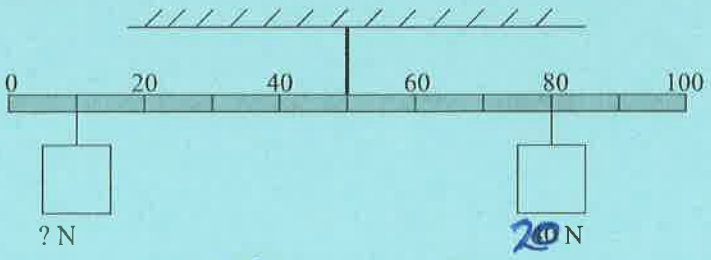
$r = 1.8\ m$

$\tau = \tau$

$F r = F r$

$300(3) = 500 r$

3. Suppose that a meterstick is supported at the center, and a 20-N block is hung at the 80-cm mark. Another block of unknown weight just balances the system when it is hung at the 10-cm mark. What is the weight of the second block?



$15\ N$

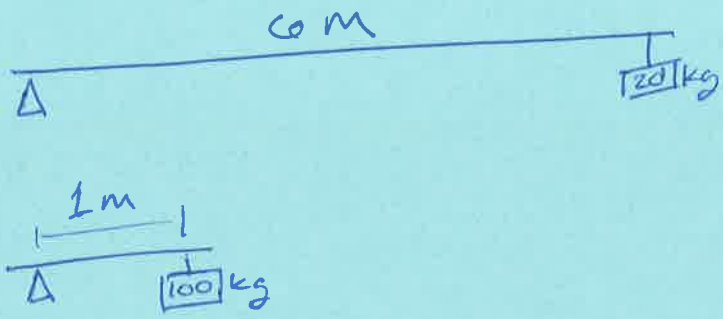
$\tau = \tau$

$F r = F r$

$F(0.4) = 20(0.3\ m)$

Sample Essay Questions – Torque

1) How could a large force somehow exert less torque than a small force? Use sample data and the equation for torque to explain your answer.

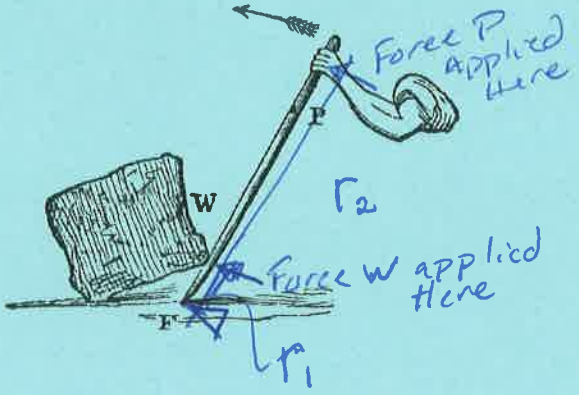


$\tau = MgR$
$= 20(9.8)(6)$
$= 1176\ Nm$

$\tau = mgr$
$= 100(9.8)1$
$= 980\ Nm$

Lever arm length is a major factor

2) When using a prybar to lift a boulder, use the concept of torque to explain how the position of the fulcrum can be moved to exert either more or less torque with the same amount of force. Mention where the fulcrum should be placed to generate the most torque.



$0 = \tau_{ccw} + \tau_{cw}$

$-\tau_{ccw} = \tau_{cw}$

~~$Wr_1 = Pr_2$~~

The shorter the r_1 distance compared to r_2 the Larger W Becomes

$\frac{Wr_1}{Pr_1} = \frac{Pr_2}{Pr_1}$

$\frac{W}{P} = \frac{r_2}{r_1}$