Problem Set 4 – circular motion & gravitation

1. An airplane flies in a horizontal circular turn with a radius of 2000 m. The mass of the airplane is 20,000 kg and the mass of the pilot is 80 kg. The speed of the airplane is a constant 300 m/s.

(a) What is the magnitude of the centripetal force on the airplane?

(b) What is the magnitude and direction of the centrifugal force on the pilot?

(c) How much time, in seconds, does the airplane need to complete the circle?

(d) How many *g’s* does the pilot experience during the turn? The number of *g’s* is the acceleration of the

pilot divided by the acceleration due to gravity.

2. A 40-kg child is on a 4 meter long swing. The swing and its chain have no mass. ***Use g = 10 m/s2.***

(a) What is the tension in the swing chain when the child is sitting motionless on the swing?

(b) What is the tension in the swing chain when the child swings through the lowest point at 3 m/s?

3. I want to swing a 2-kg object in a horizontal circle at the end of a 1.5-m long rope.

I exert a force of 100 N on the rope.

(a) What is the speed of the object?

(b) What is the magnitude and direction of the acceleration of the object?

4. A 60-kg person rides a roller coaster. The person and the cart the person is riding in goes through a vertical loop with a diameter of 8 meters. The speed of the cart is 20 m/s at the top of the loop. The cart and person are upside down at the top of the loop.

(a) What is the magnitude and direction of the centripetal force on the person at the top of the loop?

(b) What is the magnitude and direction of the force of gravity on the person at the top of the loop?

(c) What is the magnitude and direction of the force the cart seat exerts on the person at the top of the loop?

5. A 60-kg person rides a roller coaster. The person and the cart the person is riding in goes through a vertical loop with a diameter of 8 meters. The speed of the cart is 20 m/s at the bottom of the loop. The cart and the person are upright at the bottom of the loop.

(a) What is the magnitude and direction of the centripetal force on the person?

(b) What is the magnitude and direction of the force of gravity on the person?

(c) What is the magnitude and direction of the force the cart seat exerts on the person?

6. In deep space, a 60 kg asteroid is 1000 m from another asteroid. The force of gravity from the second asteroid on the 60-kg asteroid is 1 X 10 -11 N. What is the mass of the second asteroid?

7. Three satellites, ***X***, ***Y***, and ***Z***, orbit the earth in circular orbits. From the information given in the table below,

calculate the acceleration, the speed, and the force of Earth’s gravity on each satellite.

|  |  |  |  |
| --- | --- | --- | --- |
| satellite | mass of satellite | orbital radius from center of Earth | mass of Earth = 6 X 10 24 kg |
| ***X*** | 1000 kg | 8 X 10 6 m |  |
| ***Y*** | 2000 kg | 8 X 10 6 m |  |
| ***Z*** | 2000 kg | 1 X 10 7 m |  |

8. The earth has a mass of 6 X 1024kg and orbits the sun in a mostly circular orbit of radius 1.5 X 1011 meters. One orbit takes the earth 365 days.

(a) Calculate the speed of the earth, in meters/second, during its orbit relative to the sun.

(b) Calculate the gravitation force the sun exerts on the earth.

(c) Calculate the mass of the sun.

ANSWERS

1. (a) 9 X 10 5 N 4. (a) 6000 N downward 6. 2500 kg

(b) 3600N outward (b) 588 N downward

(c) 41.9 s (c) 5412 N downward 7. ***X*** 6.25 m/s2; 7072 m/s; 6250 N

(d) 4.6 *g’s*  ***Y*** 6.25 m/s2; 7072 m/s; 12500 N

***Z*** 4.00 m/s2 6330 m/s; 8000 N

2. (a) 400 N 5. (a) 6000 N upward

(b) 490 N (b) 588 N downward 8. (a) 3 X 104 m/s

(c) 6588 N upward (b) 3.6 X 1022 N

3. (a) 8.7 m/s (c) 2 X 1030 kg 🡪 340,000 X mass earth

(b) 50.5 m/s2