SECTION B – Circular Motion

1. Newton’s third law

2. \( F = \frac{mv^2}{r} \); \( v = \sqrt{\frac{Fr}{m}} \); all other variables being constant, if \( r \) is quadrupled, \( v \) is doubled

3. With acceleration south the car is at the top (north side) of the track as the acceleration points toward the center of the circular track. Moving east indicates the car is travelling clockwise. The magnitude of the acceleration is found from \( a = \frac{v^2}{r} \)

4. The frictional force acts as the centripetal force (toward the center)

5. Acceleration occurs when an object is changing speed and/or direction

6. Velocity is tangential, acceleration points toward the center of the circular path

7. To move in a circle, a force directed toward the center of the circle is required. While the package slides to the right in the car, it is actually moving in its original straight line path while the car turns from under it.

8. \( a = \frac{v^2}{r} \) and \( v = \frac{2\pi}{T} \) giving \( a = 4\pi^2r/T^2 \)

9. Once projected, the ball is no longer subject to a force and will travel in a straight line with a component of its velocity tangent to the circular path and a component outward due to the spring

10. There is a normal force directed upward and a centripetal force directed inward.

11. \( a = \frac{v^2}{r} \) where \( v = 2\pi f \) and \( f = 2.0 \text{ rev/sec} \)

12. At Q the ball is in circular motion and the acceleration should point to the center of the circle. At R, the ball comes to rest and is subject to gravity as in free-fall.

13. The net force and the acceleration must point in the same direction. Velocity points tangent to the objects path.

14. The centripetal force is provided by the spring where \( F_C = F_s = kx \)

15. In the straight sections there is no acceleration, in the circular sections, there is a centripetal acceleration

16. Once the stone is stuck, it is moving in circular motion. At the bottom of the circle, the acceleration points toward the center of the circle at that point.

17. Feeling weightless is when the normal force goes to zero, which in only possible going over the top of the hill where \( mg \) (inward) – \( F_N \) (outward) = \( mv^2/R \). Setting \( F_N \) to zero gives a maximum speed of \( \sqrt{gR} \)

18. Centripetal force points toward the center of the circle

19. While speed may be constant, the changing direction means velocity cannot be constant as velocity is a vector

20. \( F = \frac{mv^2}{r} \). \( F_{new} = (2m)(2v)^2/(2r) = 4(mv^2/r) = 4F \)

21. Assuming the track is circular at the bottom, the acceleration points toward the center of the circular path

22. Average speed = (total distance)/(total time). Lowest average speed is the car that covered the
least distance

23. As all the cars are changing direction, there must be a net force to change the direction of their velocity vectors D

24. \[ F = \frac{mv^2}{r}; \] \[ v^2 = \frac{rF}{m}, \] if \( r \) decreases, \( v \) will decrease with the same applied force. Also, \( v = 2\pi f \) so \[ 4\pi^2 r^2 f = \frac{rF}{m}, \] or \( f = \frac{F}{4\pi^2 rm} \) and as \( r \) decreases, \( f \) increases. D

25. \( f = 4 \text{ rev/sec.} \) \( a = \frac{v^2}{r} \) and \( v = 2\pi f \) D

26. \( F = \frac{mv^2}{r} \) D

27. There is a force acting downward (gravity) and a centripetal force acting toward the center of the circle (up and to the right). Adding these vectors cannot produce resultants in the directions of B, C, D or E. A

28. \( \Sigma F = ma; \) \( mg + F_T = \frac{mv^2}{r} \) giving \( F_T = \frac{mv^2}{r} - mg \) B

29. At the top of the circle, \( \Sigma F = F_T + mg = \frac{mv^2}{R} \), giving \( F_T = \frac{mv^2}{R} - mg \). At the bottom of the circle, \( \Sigma F = F_T - mg = \frac{mv^2}{R} \), giving \( F_T = \frac{mv^2}{R} + mg \) The difference is \( (\frac{mv^2}{R} + mg) - (\frac{mv^2}{R} - mg) \) B

30. At the bottom of the swing, \( \Sigma F = F_T - mg = ma_c \); since the tension is 1.5 times the weight of the object we can write \( 1.5mg - mg = ma_c \), giving \( 0.5mg = ma_c \) B

31. \( F_N = \frac{mv^2}{r} \)
\( F_f = mg \) to balance
\( \mu F_N = \mu \frac{mv^2}{r} = mg \), where \( v = 2\pi f \) which gives \( \mu = \frac{g}{4\pi^2 rf^2} \)
Be careful! \( f \) is given in rev/min (45 rev/min = 0.75 rev/sec) and 8.0 m is the ride’s diameter C