PHYS2350 EV1 Fall 2017 Exam 2 Review Questions

Hints and Answers

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Chapter 5: Circular Motion & Gravity

1. A tetherball attached to a rope of 30cm length takes 1.5s to make one revolution. What is the linear speed of the tetherball?

   Hint: you can define a linear speed in terms of an orbital period by imagining how many circumferences you could travel per second.

   Answer: 1.26m/s

2. A rollercoaster goes through a loop-the-loop, reaching a speed of 20m/s at the top of the loop. If the loop has a radius of 15m, and the rollercoaster car has a mass of 600kg including passengers, what is the magnitude of the normal force on the car at the top of the loop?

   Hint: recall that the normal force always points to push you *away* from a surface; it doesn't always have to point up. Also, bear in mind that this is a circular motion problem.

   Answer: 10,120 N

3. A satellite in orbit around the Earth feels weightless because:

   (a) It's too far from Earth to feel gravity
   (b) The gravitational force from Earth is balanced by the centrifugal force on the satellite
   (c) The gravitational force from Earth is balanced by the centripetal force on the satellite
   (d) The acceleration due to gravity matches the centripetal acceleration of the satellite

   Hint: the gravitational force is proportional to $1/r^2$; how far apart would two objects be to no longer experience a gravitational force? Also, recall the direction of a centripetal force.

   Answer: (d)

4. A 40kg child is on a swing supported by two 3m chains. At the child's lowest point in the swing, the tension in each chain is 350N. What is the speed of the child at the lowest point?

   Hint: don't think of this problem as a child sitting in and being supported by a seat; imagine this problem as if it were an object hanging at the end of the chains being supported by the tension in them.

   Answer: 4.81m/s

5. If the mass of Earth was doubled, what would the period of the orbit around the Sun be?

   Hint: in Kepler's third law, what is the meaning of the variable M? Kepler's third law is given on the formula sheet for the exam, should you need it.

   Answer: 1 year

6. The weight of a 100kg man on a planet with one-half the mass and twice the radius of Earth would be what?

   Hint: weight is defined the same on any planet as it is on Earth, just under the influence of different gravity.

   Answer: 122.5N

7. Two identical satellites, A and B, are in orbit around Earth. Satellite A is in orbit at a distance of r from the center of the Earth, while satellite B is in orbit at a distance of $2r$ from the center of the Earth. Compared to the centripetal force on satellite A, the centripetal force on satellite B is what?

   Hint: what force is responsible for the satellite remaining in orbit? That is, since the satellite wants to move in a straight line past the Earth, what force is responsible for turning it? Compare the magnitudes of this force.

   Answer: The centripetal force on B is one-fourth that on A.

8. In an x, y-coordinate system, a 2kg mass lies at the origin, a 1.2kg mass lies at (1m, 0), and a 2.5kg mass lies at (0, 0.5m). What is the magnitude and direction of the net gravitational force on the mass at the origin due to the other two masses?

   Hint: this problem involves vector addition. Find the magnitudes of each gravitational force, in the usual way, find the direction of each force (gravity is always an attractive force), and then break each force up into their components and add (with the appropriate sign), like you would on a free body diagram, to find the components of the net force. From there, it's just a matter of trigonometry to find the magnitude and direction.

   Answer: the magnitude of the net force is 1.34×10^{-9}N and the direction is 84^o measured counter-clockwise from the $+x$-axis.

Chapter 6: Work & Energy

1. A 10kg box is pushed up a 30^o, frictionless incline at a constant speed. After the box is pushed 30cm, how much work has been done by the pushing force, by gravity, and by the normal force? What is the total work done?

   Hint: recall the work-energy theorem and see what it says about an object moving at a constant speed. Further, don't forget about the angle between the forces and the displacement of the object up the slope.

   Answer: $W_{\text{push}} = 14.7$J, $W_{\text{gravity}} = -14.7$J, $W_N = 0$, and $W_{tot} = 0$

2. A box of mass m needs to be raised from the floor to a height of h. Which of the following methods requires less work to raise the box: pushing the box up an incline at a constant speed or raising the box straight up at a constant speed?

   Hint: consider when a work is path-dependent and when a work is path-independent. You're going to be pushing that box against gravity and so you'll be doing work against gravity; does gravity care what path you take or not?

   Answer: Same amount of work either way.

3. A weightlifter lifts a 80kg barbell from the front of his hips to his collarbone, about 0.7m. During each cycle (a lift up and then a lowering down), what is the total work done on the barbell? In order to move the barbell at a constant velocity, how much work is done by the weightlifter each time he lifts the barbell?

   Hint: consider the barbell beginning and ending each cycle at rest. Also, for the lifting of the barbell, know that he's doing work against gravity.

   Answer: $W_{\text{cycle}} = 0$ and $W_{\text{lift}} = 548.8\text{J}$

4. A block of mass m is dropped from the fourth floor of a building, and hits the ground with a speed of v. From what floor should it be dropped to double the speed with which it hits the ground?

   Hint: this problem is solvable using kinematics or energy physics, since acceleration is constant; you just need to find a way to relate the distance traveled through the air to the speed gained.

   Answer: the 16th floor

5. A 5kg box slides along a floor at a speed of 10m/s when suddenly it encounters a patch of friction that slows it to a stop over a distance of 10m. How much work was done on the box due to friction? What is the coefficient of kinetic friction between the box and the floor?

   Hint: you can use the work-energy theorem to answer both questions; think about the amount of work being done by the other forces on the box.

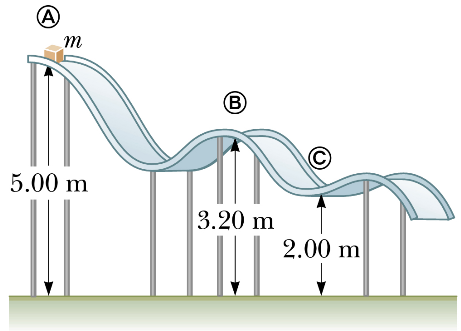
   Answer: $W_f = 250\text{J}$ and $\mu_k = 0.51$

6. A 10kg cannonball is fired at an initial speed of 50m/s at a launch angle of 30^o. What is the initial kinetic energy of the cannonball? What is the kinetic energy of the cannonball at the peak of its trajectory? How much potential energy did the cannonball gain during the rise to the peak?

   Hint: the kinetic energy depends upon speed, not velocity. Also note that the speed isn't zero at the peak. Aside from that bit of trickery, the problem is a straightforward energy conservation problem: where does the kinetic energy from the bottom to the peak go?

   Answer: $K_i = 12,500\text{J}$, $K_{\text{peak}} = 9375\text{J}$, and $\Delta U = 3125\text{J}$

7. If the object in the figure below is released from rest at point A, what will its speed be at point B? What will its speed be at point C? Assume there's no friction along the slide.



Hint: acceleration isn't a constant here, since the surface curves, so kinematics can't be used. Since there is no friction, no non-conservative forces are acting on the object either. What would be the best way to solve this problem, which relates a change in height to a change in speed, then?

Answer: $v_B = 5.94\text{m/s}$ and $v_C = 7.67\text{m/s}$

8. Referring again to the figure above, if the object has a mass of 5kg, and is released from rest at point A, but this time there is a bit of friction doing -10J of work along the way, what will be the speed of the object at point B?

   Hint: in this case, energy isn't conserved, but there is still a way to relate the final energies to the initial energies. Also, don't forget the sign of the work done by friction. It's very important!

   Answer: $v_B = 5.59\text{m/s}$

9. On the moon Io of Jupiter, the acceleration due to gravity is about 1.81m/s^2. Io is extremely volcanic, and plumes of ash can reach as high as 500km above the surface. At what speed must the ash be ejected from a volcano on Io to reach that height? What about on Earth?

   Hint: energy conservation doesn't change based on where you are in the solar system; kinetic energy is still converted into gravitational potential energy as you go up. The question is, how does the gravitational potential energy change between Earth and Io? Take a look at the formula for potential energy and check what about it would change.

   Answer: $v_{\text{Io}} = 1345\text{m/s}$ and $v_{\text{Earth}} = 3130\text{m/s}$

Chapter 7: Momentum

1. A 3kg rifle is at rest with a 100g bullet loaded. If the bullet exits the barrel at 300m/s, at what speed does the rifle recoil?

   Hint: prior to the bullet being fired, what's the state of motion of the gun-bullet system? How did the bullet gain its motion? Does it do so for free, with no affect on the gun? Bare in mind that everything that goes on between the bullet and the gun goes on inside the gun, i.e. internal to their system.

   Answer: 10m/s

2. A 10kg block slides across a frictionless floor at 25m/s when suddenly a 2kg box falls on top of it. At what speed will the boxes move after the smaller box has landed?

   Hint: as the box lands on the block, a force is exchanged between them, but this would be a force internal to their system. What is the main consequence of a system on which no external forces act? Also, even though the box is falling, ignore the y-direction; this problem focuses entirely on the x-direction.

   Answer: 20.8m/s

3. While you're fixing a roof, a shingle slides off and falls to the ground. During the fall, which of the following is true?

   (a) Its momentum and energy are conserved
   (b) Its momentum is conserved, but not its energy
   (c) Its energy is conserved, but not its momentum
   (d) Neither its energy nor its momentum are conserved

   Hint: think about the actual motion of the shingle. Also, what forces are acting on the shingle as it falls? Do they conserve energy or not?

   Answer: (c)

4. A 3000kg truck moving at 10m/s collides with a 2000kg car moving at 15m/s, resulting in the cars being smushed together and the wreckage sliding at 2m/s. Which vehicle experiences the greater change in momentum during the collision? Which vehicle experiences a greater change in kinetic energy?

   Hint: Newton's second law relates an object's change in momentum to the force it experiences. What does Newton's third law say about the force between these cars during a collision? Combining those two laws will answer the first question. Even though during a collision momentum is conserved, kinetic energy doesn't have to be conserved and it most often is not. Calculating the change is as simple as finding the kinetic energy before and after the collision and taking the difference.

   Answer: both vehicles experience the same magnitude of change in momentum (though they point in opposite directions), but the car experiences a greater loss of kinetic energy

5. A collision occurs between two objects. Object 1 has a mass m_1 and object 2 has a mass m_2. During the collision, which of the following statements about the forces and accelerations experienced by the masses is true?

   (a) $F_1 = F_2 \quad \text{and} \quad a_1 = \frac{m_2}{m_1} a_2$

   (b) $F_1 = \frac{m_2}{m_1} F_2 \quad \text{and} \quad a_1 = \frac{m_2}{m_1} a_2$

   (c) $F_1 = \frac{m_2}{m_1} F_2 \quad \text{and} \quad a_1 = a_2$

   (d) $F_1 = F_2 \quad \text{and} \quad a_1 = a_2$

Hint: think of Newton's law governing the forces objects put on each other, and then think about how those forces relate to the acceleration of the object, which is governed by another of Newton's laws.

Answer: (a)

6. A 2kg ball is moving horizontally at a speed of 20m/s when it bounces off a wall. If the ball leaves the wall moving horizontally at 15m/s, what was the change in the ball's momentum?

   Hint: the change in momentum is dependent upon the change in velocity, not speed, and the direction of velocity matter in the calculation. Make sure to establish a positive direction!

   Answer: 70Ns

7. A 5kg mass is moving in the $+x$-direction at a speed of 15m/s when it collides with a 3.5kg mass moving in the -x-direction at a speed of 3m/s. If the collision is elastic, what are the speeds and directions of each mass after the collision?

   Hint: since the collision is elastic, you can use the special equation associated with elastic collisions. Besides that, there's not much physics about these problems; just solve the system of equations, plug in your numbers, and get your answers. Don't forget about the sign of velocity!

   Answer: $v_{1f} = +0.18$m/s and $v_{2f} = +18.2$m/s