General Physics
Physics 101
Final – Fall 2014
Thursday – 12/11/14
Prof. Bob Ekey

Name (print):_____

I hereby declare upon my word of honor that
I have neither given nor received unauthorized
help on this work.

Signature:_____

Part I. Multiple Choice (3 pts each)

Instructions:

Please clearly circle one and only one answer for each of the following.
Show all of your work. Partial credit may be given if you include your work.

Questions:

1. A mass-spring system is in simple-harmonic motion in the horizontal direction. If the mass is 0.25 kg, the spring constant is 12 N/m and the amplitude is 15 cm, what is the speed of the mass at a half-amplitude position?

(a) 0.65 m/s
(b) 0.28 m/s
(c) 0.15 m/s
(d) 0.90 m/s

2. A 100 kg m^2 turntable rotates at an angular speed of 10.0 rad/s. A solid disc of radius 0.500 m is dropped onto the turntable and the system now rotates at 5.00 rad/s. What is the inertia of the solid disc? Assume friction doesn't exist.

(a) 100 kg m^2
(b) 200 kg m^2
(c) 300 N/(ms^2)
(d) 500 Nm

3. A 20.0 kg child slides down a 3.00 m high playground slide. She starts from rest, and her speed at the bottom is 3.0 m/s. How much work is done by friction during the slide?

(a) - 6.8 x 10^2 J
(b) + 498 J
(c) – 0.50 kJ
(d) + 5.9 x 10^2 J

4. Which of the following statements is false.

(a) Linear momentum can always be conserved.
(b) Two vectors of unequal magnitude cannot add to zero.
(c) The center of mass can lie outside of an object.
(d) The unit "candela" is not an SI base unit.

5. In the morning, I drive from my house to daycare, which is 1.0 mile west of my house. I then drive to Mount, which is 1.0 mile east of my house. The trip from my house to daycare takes 3.0 minutes, and the trip from daycare to Mount takes 6.0 minutes. What is my average velocity during my entire trip? Assume all 1D motion.

(a) 0.17 miles/min
(b) 0.11 miles/min
(c) 0.00 miles/min
(d) 0.33 miles/min

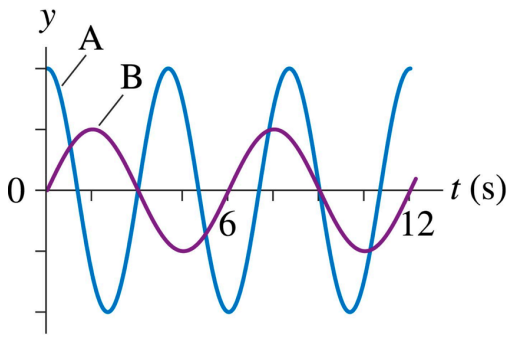
6. You and a friend are using a spring for a tug-of-war. Each of you pull on an end of the spring with a force of 100 N, and the spring stretches by 40 cm. After your dramatic loss, you practice by attaching one end of the spring to a wall and pull on the other end with 100 N of force. How far does the spring stretch now?

(a) 10 cm
(b) 20 cm
(c) 40 cm
(d) 80 cm

7. A 20.0 kg cannon ball is launched vertically with an initial velocity of +100 m/s from a height of 30.0 m with respect to the ground. If the ball lands back into the cannon (luck), how long did the entire motion take?

(a) 0.00 ms
(b) 20.4 s
(c) 10.3 s
(d) 4.52 s

8. The two graphs shown are for two different vertical mass-spring systems. For A, what is the frequency?



(a) 12 Hz
(b) 0.25 1/s
(c) 0.17 Hz
(d) 8.3 mHz

9. A truck traveling at 100 mph crashes into a stationary compact car. Which experiences the larger impulse?

(a) Truck
(b) Car
(c) Both experience the same impulse
(d) Need more information

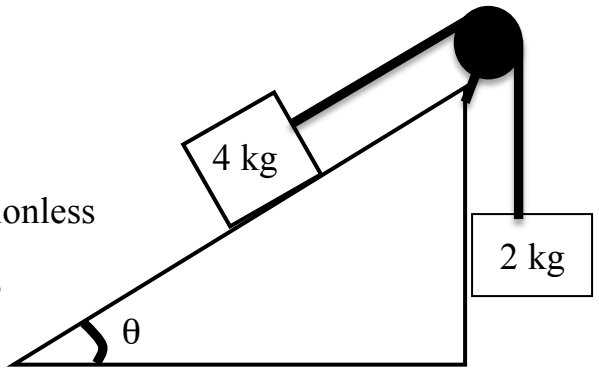
10. In the Hobbit movie, Gandalf is the last to be rescued from a tree that is about to fall from the cliff where it is rooted. The 1000 kg tree is approximately 30.0 m tall, and can be considered a rigid rod. Gandalf (100 kg) is standing at the top of the now-sideways tree. What is the torque applied to the roots of the tree?

(a) 1.80×10^4 Nm
(b) 1.76×10^5 Nm
(c) 3.23×10^5 Nm
(d) 9.75×10^4 Nm

11. A 100g ball moving to the right at 4.0 m/s collides head-on with a 200 g ball that is moving to the left at 3.0 m/s. If the collision is elastic, what is the speed of the 200g ball after the collision?

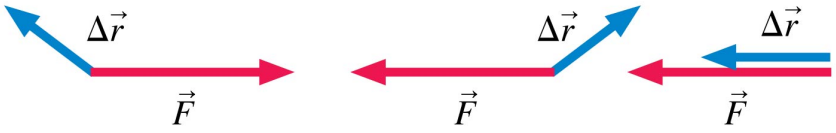
(a) 1.7 m/s
(b) 0.67 m/s
(c) 5.3 m/s
(d) 3.6 m/s

12. A 4.0 kg box is on a frictionless 20º ramp and is connected via a massless string over a massless, frictionless pulley to a hanging 2.0 kg weight. If you gently release the box, which way will it move on the ramp?



(a) Up the ramp
(b) Down the ramp.
(c) It will not move.
(d) Need more information

13. A constant force $\vec{F}$ pushes a particle through a displacement $\Delta\vec{r}$. In which of these three cases does the force do negative work?



(a) (b) (c)

Both (a) and (b)

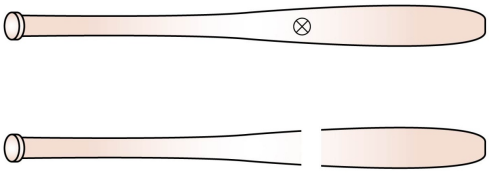
(d)

14. A pickup truck with a steel bed is carrying a steel file cabinet. If the truck's speed is 15 m/s, the shortest distance the truck can stop without the file cabinet sliding is 14.3 m. What is the coefficient of friction between the truck and file cabinet?

(a) 0.80
(b) 0.60
(c) 0.054
(d) 1.6

15. A horizontal spring is attached to a cart that oscillates between the 10 cm and 60 cm from the end of the spring. If the cart makes 10 full oscillations in 30 second, what is the maximum acceleration of the system?

(a) 0.52 m/s^2
(b) 2.2 m/s^2
(c) 1.1 m/s^2
(d) 1.7 m/s^2



16. A baseball bat is cut in half at its center of mass ⊗. Which end is heavier?

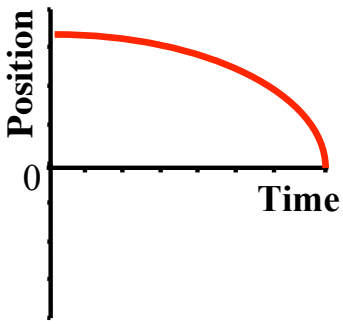
(a) The handle end (left end).
(b) The hitting end (right end).
(c) The two ends weigh the same.
(d) Not enough information

17. You are spinning 1.0 kg of water vertically in a bucket. Your arm has a radius of 0.75 m, and the bucket spins at a constant 5.0 rad/s. What is the normal force exerted on the water by the bucket when the bucket is at the top of its motion?

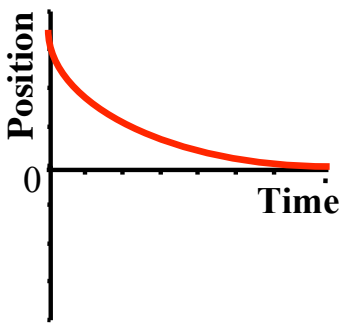
(a) 24 N
(b) 9.0 N
(c) 28 N
(d) 19 N

18. Which of the following position versus time graphs could represent the motion diagram shown.

(a)



(b)



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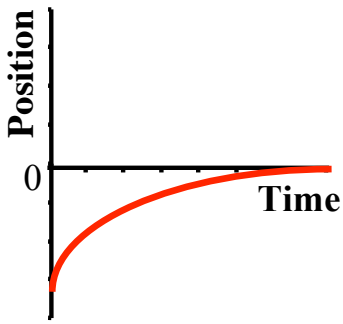
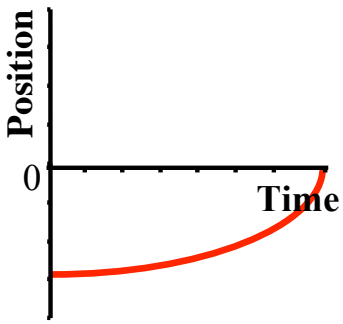
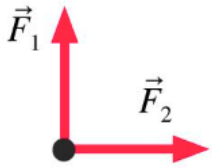
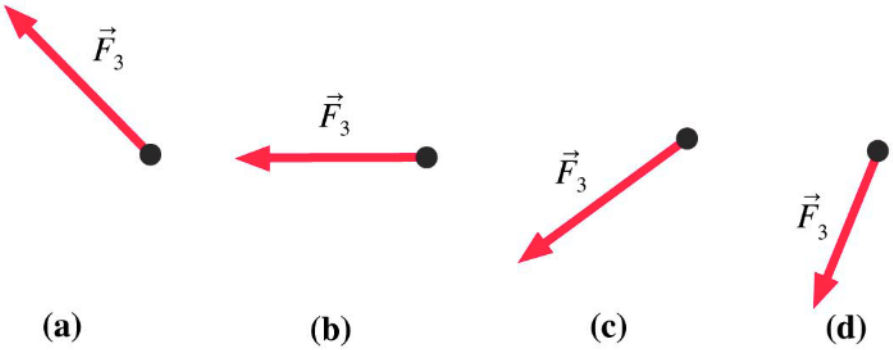


(d)



19. Two of three forces are shown. If the net force points to the left, which vector could represent the third force?



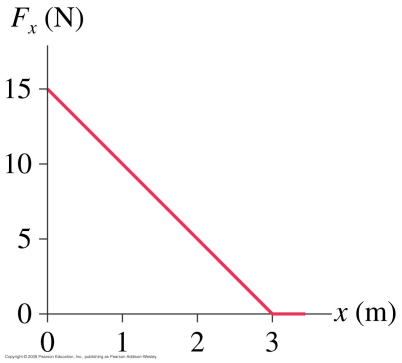


20. The Kessel Run involves flying a spaceship through a cluster of blackholes known as the Maw. Ignoring any alterations to the space-time continuum, the Maw has an area of 42 square parsecs. If 1 parsec is 3.085×10^{16} meters, what is the SI equivalent value of this area?

(a) 1.295×10^{18} m^2
(b) 9.5×10^{32} m^2
(c) 4.0×10^{34} m^2
(d) 1.3×10^{18} m^2

21. A 3.0 cm diameter drill rotates from rest to an operational angular speed of 1000 rad/s, while it experiences an angular acceleration of 100.0 rad/s^2. What is the total angular distance traveled by the drill during this process?

(a) 5.0×10^3 rad
(b) 5.0 rad
(c) 1.5×10^4 rad
(d) 5000 rad



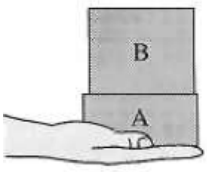
22. A 500 g particle moving along the x-axis experiences the force shown. What is the change in kinetic energy of the particle after traveling 2.0 m?

(a) 20 J
(b) 13 Nm
(c) 23 J
(d) 45 Ns

23. Astronauts on their first trip to Mars take along a pendulum that has a period on earth of 1.50 s. If the period on Mars turns out to be 2.45 s, what is the free-fall acceleration on Mars?

(a) 3.67 m/s^2
(b) 26.1 m/s^2
(c) 6.00 m/s^2
(d) 0.918 m/s^2

24. Block A and B are 5.0 kg and 10.0 kg respectively. As shown, these blocks are lifted with a uniform acceleration of +2.0 m/s^2. What is the magnitude of the force of block A on block B?



(a) 1.2 x 10^2 N
(b) 20 N
(c) 78 N
(d) 59 N

25. A 0.50 kg ball is spun in a horizontal circle at radius of 0.50 m and the tension in the string is 50 N. What is the angular velocity of the motion, assuming it is traveling at constant speed?

(a) 14 rad/s
(b) 3.5 rad/s
(c) 7.1 rad/s
(d) 10 m/s

26. An object is held in place by friction on an inclined surface. The angle of incline is increased until the object starts moving. If the surface is kept at the angle, the object

(a) slows down.
(b) moves at uniform speed.
(c) speeds up.
(d) none of the above

27. A ball thrown horizontally at 25 m/s travels a horizontal distance of 50 m before hitting the ground. From what height was the ball thrown?

(a) 50 m
(b) 9.8 m
(c) 70 m
(d) 20 m

28. Bob throws a 500 g rock while moving his hand forward 2.0 m during the throw. If Bob does 2.3×10^2 J of work on the rock, how fast is the rock traveling after the throw?

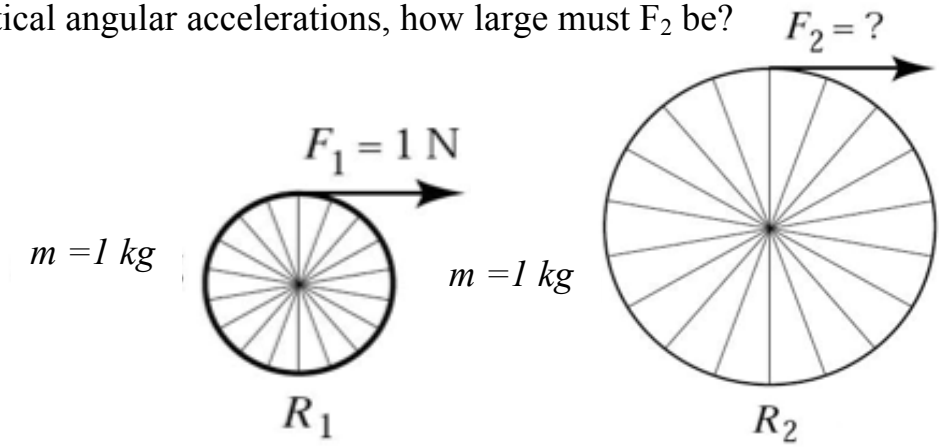
(a) 9.2×10^2 m/s
(b) 43 m/s
(c) 1.0 m/s
(d) 30 m/s

29. Two wheels are rolling towards an inclined plane with the same velocity without slipping. Wheel A can be considered a solid disc while wheel B can be considered a hoop. Which wheel reaches a higher vertical distance on the inclined plane?

(a) Wheel A
(b) Wheel B
(c) They both reach the same height
(d) need more information

30. Two wheels with fixed hubs, each having a mass of 1.0 kg, start from rest, and have the forces shown below applied to them. Assume the hubs and spokes are massless, so that the rotational inertia is $I=mR^2$ and also assume that $R_2 = 2R_1$.
In order to impart identical angular accelerations, how large must F_2 be?

(a) 4.0 N
(b) 0.25 N
(c) 0.50 N
(d) 2.0 N



Part II. Short answer problems (12 pts each)

Instructions:

Solve four of the following six problems. If you try to solve all six problems, please clearly indicate which problems you wish to have graded. If you do not indicate this, I will assume you want me to grade problems one, two, three and four.

Please show all of your work, including equations without numbers.
Please provide units with all answers.
Partial credit may be given if you include your work.

Question 1. **Grade this problem? Yes or No (circle one)**

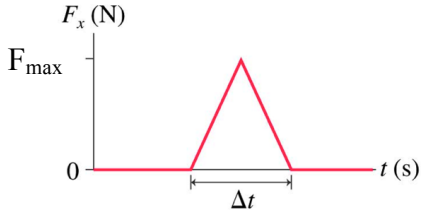
In Mission Impossible Ghost Protocol, Ethan Hunt (70 kg) drives a BMW off a parking tower, and lands 5 stories below, approximately a 20.0 m drop. The initial velocity of the car is 1.00 m/s horizontally.

(a) Draw a complete motion diagram of the car's flight from the moment the car begins free-fall to right before it impacts the ground.

(b) How long did it take for the car to fall 5 parking garage stories?

(c) What was the impact speed of the car?

(d) As Ethan Hunt was in the car as it crashed, he experiences the following force as shown. It takes him approximately 0.12 seconds to come to rest when impacting the air bag. What is the maximum force (mag.) he experiences during the collision?



Question 2. Grade this problem? Yes or No (circle one)

In Captain America - Winter Soldier, there is a scene where the Winter Soldier throws Cap's shield at him and Captain America (Cap) catches the shield and he and the shield slide backwards to rest (on a level roof). We'll assume he travels a distance of 4.00 m to come to rest, and that he weighs 100 kg, and the shield weighs 15.0 kg. The coefficient of friction between his rubber soles and concrete is 0.200.

(a) What is the magnitude and direction of the friction force acting on the system (cap+shield) as he comes to rest?

(b) Determine the velocity of the system immediately after Cap catches his shield.

(c) During the slide is mechanical energy conserved? Explain your answer with words and possibly equations. No calculations are necessary.

(d) What is the velocity of the shield prior to being caught by Captain America?

Question 3. Grade this problem? Yes or No (circle one)

I was watching a Looney Toons where Sylvester the cat was chasing Tweety bird. Sylvester jumped onto Tweety's cage, and he and the cage fell to the earth. Luckily it was connected to a spring on the ceiling. We can assume Sylvester has a mass of 10 kg (big cat) and the cage has a mass of 2.0 kg. The cage initially was at the ceiling, and the system starts from rest on the floor, a vertical distance of 3.0 m from the ceiling.

(a) If the equilibrium position of the Cage + Sylvester is 1.0 m from the floor, what is the spring constant of the spring?

(b) What is Sylvester's maximum velocity and state where this occurs?

(c) Where are the cage and Sylvester when the system is moving at half of the max velocity? State your answer as a displacement from the equilibrium position.

(d) If Tweety bird would join the system, what would happen to the oscillation frequency? Assume that Tweety's mass is non-negligible. No calculations are necessary, but words and equations are required.

Question 4. Grade this problem? Yes or No (circle one)

I was given a toy that flies up into the air using a balloon and a rotor (thrust force). The toy has a total mass of 200g, and it can move 2.5 m from the floor to the ceiling in 1.5 s. Assume it increases its speed uniformly from rest and ignore air resistance.

(a) What is the acceleration of the toy as it moves from the floor to the ceiling?

(b) As the toy rises into the air. What are signs of the work done by gravity, work done by the thrust force and the net work? Be sure to explain and/or justify your answer with words and possibly equations.

(c) What is the net work done on the toy as it rises into the air?

(d) Using the concept of net work, determine the work done by the thrust force.

Question 5. **Grade this problem? Yes or No (circle one)**

Another toy I was given to play with was a circular disc with wings that you launch from rest with a zip cord. We'll treat the system as a solid circular disc that has a diameter of 18 cm and mass of 25 g. The zip cord pulls on the disc at a radius of 5.0 cm, and we'll assume a constant pull force of 25 N.

(a) If the angle between the force from the zip cord and radius is 80º, what is the net torque applied to the system as the cord is pulled?

(b) Assuming all the torque found in (a) is used to spin the disc, what is the angular acceleration of the disc as the cord is pulled?

(c) If it takes 50 ms to pull the cord, what is the angular velocity of the disc at the end of the pull?

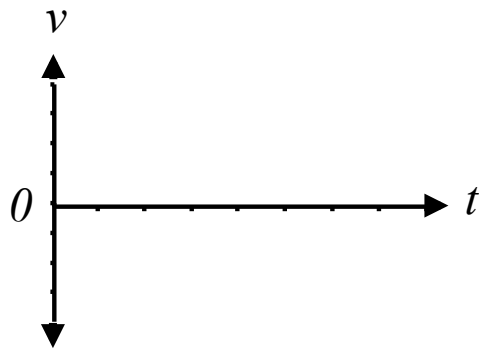
(d) How does the tangential acceleration of a point on the edge of the disc compare with that of a point closer towards the axis of rotation. No calculations are necessary in your answer, but words and equations are.

Question 6. **Grade this problem? Yes or No (circle one)**

My 2.3 year old and I play a lot of cars, he likes saying "Vrroom" as we slide the cars down a ramp. We'll define down the ramp as the positive direction, the mass of the car to be 50 g and the angle of the ramp as 30º with respect to the horizontal. We'll also assume my son releases the car with an initial velocity of 2.0 m/s and a constant kinetic friction force of 0.50 N (magnitude) acts on the car.

(a) What is the acceleration of the car as it moves down the ramp?

(b) Sketch a velocity vs time plot that could represent the motion of the car as it moves down the ramp. Please explain the shape & meaning of the graph.



(c) What is the velocity of the car when it reaches the end of 0.25 m long ramp?

(d) One of the cars typically falls apart at the bottom of the ramp, with the top half separating from the bottom half ($m_{top}=m_{bottom}$). If after separating the top half leaves with the velocity found in (c), what would the velocity be of the bottom half. Please use conservation of momentum in your calculation and assume all 1D motion.