FINAL REVIEW: PRACTICE PROBLEMS

UNIT 1: MOTION BASICS

1. A particle's velocity as a function of time is given by $v(t) = 4t - 3t^2$ (measured in m/s), and its position at time t=0 is x=4m.

a. Find the particle's acceleration as a function of time.

b. Find the particle's position as a function of time.

c. Find the particle's position as it reaches its maximum velocity.

2. A car's velocity v_1 at one moment is $(15\hat{i} - 13\hat{j})$m/s, and then 3.5 seconds later its velocity v_2 is $(9\hat{i} + 12\hat{j})$m/s.

a. Calculate the car's change in velocity $v_2 - v_1$ in unit vector notation.

b. Calculate the magnitude and angle of the car's average acceleration during the 3.5 second interval.

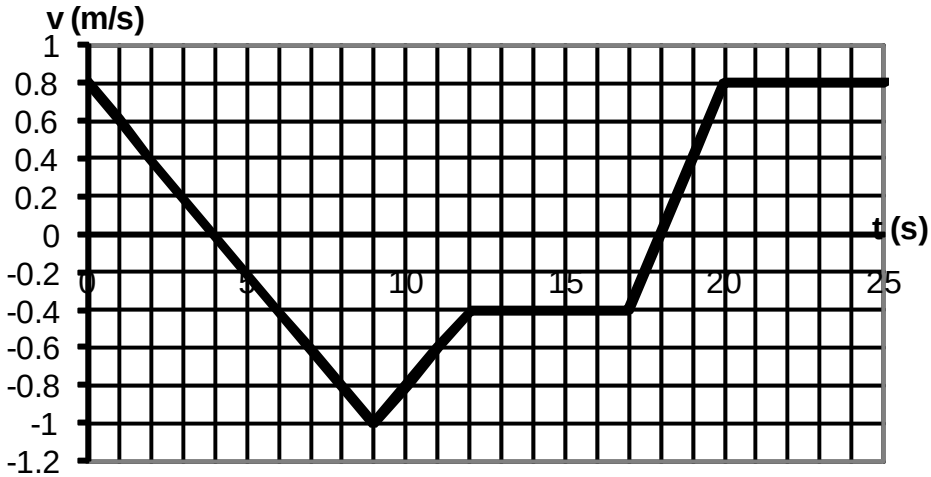
3. A ball is thrown upward from ground level at an angle of 25° above the horizontal. It passes its maximum height, and then lands back on the ground 30m away from its starting position.

a. What was the ball's initial velocity?

b. What was the maximum height reached by the ball?

4. A particle is moving clockwise with uniform circular motion in a horizontal xy plane. Its acceleration at t_1=3s is $(5\hat{i} - 8\hat{j})$m/s^2, and at t_2=6s it is $(-8\hat{i} - 5\hat{j})$m/s^2. Calculate the radius of the particle's circular path.

5. A particle moves on a straight horizontal track. The graph of velocity v versus time t for the particle is given.



a. Indicate every time t for which the particle is at rest.

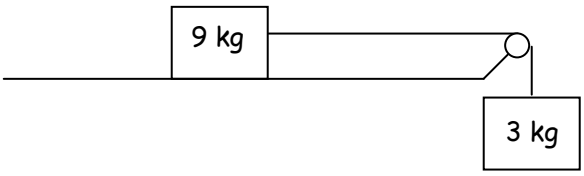
b. Indicate every time interval for which the speed (magnitude of velocity) of the particle is increasing.

c. Determine the displacement of the particle during the time interval from t=18s to t=25s.

UNIT 2: FORCES, NEWTON'S LAWS, & CIRCULAR MOTION

6. The coefficient of static friction between a 3kg crate and the 35° incline it sits upon is 0.200. This friction is not enough to keep the box from sliding down the incline. What is the minimum 'squeezing' force that must be applied to the box, perpendicular to the incline, to keep the crate from sliding?

7. The two blocks in the picture are being held in place, and are then released from rest. Use force ideas and kinematics to find the following, assuming the table and pulleys are frictionless: the tension in the cord connecting the blocks, the acceleration of the 3kg block as it descends, and the speed of the 3kg block as it strikes the floor, 1.2m below where it started.



8 A 2000kg car rounds a circular turn of radius 30m. If the road is flat and the coefficient of static friction between the tires and road is 0.67, what is the fastest velocity the car can have as it rounds the corner without skidding?

9. A roller-coaster car has a mass of 600kg when fully loaded with passengers. The vehicle is approaching the top of a hill that is shaped like part of a circle of radius 20m.

a. What is the maximum speed the car can have when it is at the top of the hill, in order for gravity to keep the car on the track?

b. What is the normal force on the car if its speed is half of the maximum calculated in part A?

10. A 25cm-diameter spherical ball of mass 0.8kg is falling in the presence of air resistance. If the ball's drag coefficient is 0.9 and the air's density is 1.19kg/m^3, calculate the terminal speed of the ball. ($F_{drag} = \frac{1}{2}C\rho Av^2$)

UNIT 3: WORK & ENERGY

11. A 3kg object slides over a frictionless xy plane, through a displacement given by $(13\text{m})\hat{i} - (5\text{m})\hat{j}$ while a constant force given by $(7\text{N})\hat{i} + (12\text{N})\hat{j}$ acts on the object.

a. Calculate the work done by the force on the object during the slide.

b. If the previous motion occurs over a time interval of 3.2 seconds, at what rate is work done on the object?

12. A force acting on a 12kg block is given by $F(x) = 4x - 5x^2$, in Newtons. Calculate the work done by the force as the block moves from x=0m to x=3.5m.

13. A 45cm-long pendulum is initially held such that it makes an angle of 25° with the vertical, and then it is thrown downward. How fast does the 1.2kg pendulum bob need to be thrown downward so that it swings down and then back up to a position vertically above its support, with a tension of exactly 6N in the string at this location?

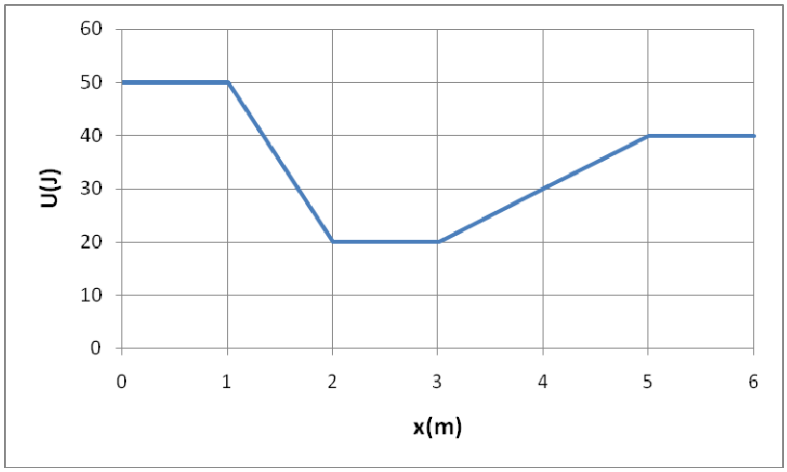
14. Starting from rest, a 20kg block slides down 4m along a frictionless ramp that is inclined at 20° to the floor. Then the block slides another 3m along the flat, horizontal floor as it slows to a stop.

a. Calculate the work done by gravity as the block slides down the ramp.

b. Use work and energy considerations to find the speed of the block at the base of the ramp.

c. Find the coefficient of friction between the block and floor.

15. The given graph shows a plot of potential energy U versus position x of a 2kg particle that can travel only along the x-axis under the influence of a conservative force. The particle is released at position x=2.5m with a velocity of 5.0m/s in the negative x-direction.



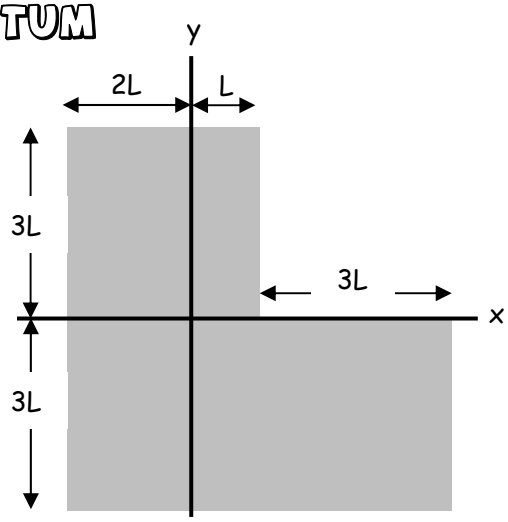
a. What is the position of the turning point on the left side of the graph?

b. What is the particle's speed at x=6m?

c. What are the magnitude and direction of the force acting on the particle at x=4m?

UNIT 4: CENTER OF MASS & LINEAR MOMENTUM

16. What are the x- and y-coordinates of the center of mass for the uniform metal plate shown in the figure, if L=5cm?



17. The force acting on a 3.2kg object is given by $F(t) = 4t - 2t^2$. Calculate the impulse on the object due to the force from time 1.2s to 4s, and also the average force during this same time interval.

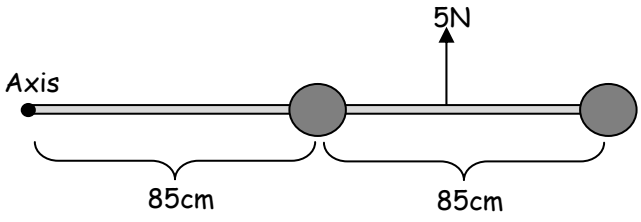
18. A 30kg disk moving at 24m/s in the positive x-direction is exploded into three pieces. After the explosion, a 17kg piece moves at 35m/s in the positive x-direction, and a 10kg piece moves at 22m/s at 20° clockwise from the negative x-axis. Calculate the magnitude and direction of the velocity of the third piece after the collision.

19. What is the launch velocity of a 100g ball fired into a 250g ballistic pendulum, if the pendulum's center of mass is raised 23cm as it swings after the collision, assuming the pendulum catches the ball when they collide?

20. A 300g object slides down a frictionless 10° incline and reaches the bottom with a speed of 4.3m/s, where it elastically collides with a 400g object at rest. After the collision, how far back up the incline (measured along the incline) does the 300g object slide before it comes to a stop?

UNIT 5: ROTATIONAL MOTION

21. Two point-masses on a frictionless horizontal plane, each with mass of 13kg, are attached to each other and to a rotation axis, by two 85cm-long thin rods of mass 8kg. The combination starts from rest, and is acted on by a 5N force that pulls perpendicularly to the length of the rods, at a location halfway between the two masses. (The force remains perpendicular to the rods even when they begin to rotate.)



a. Calculate the rotational inertia of the combination.

b. Calculate the rotational acceleration of the combination.

22. A 3kg box is tied to a string that is wound tightly around the outside of a 2kg disk of radius 15cm. The disk is mounted on a fixed axis through its center (to behave like a pulley), and the box is released from rest to fall and unwind the disk. If there is no friction at the disk's axis, and if the string does not slip along the edge of the disk, find the speed of the box after it has fallen 92cm.

23. A solid sphere rolls without slipping down a 24° incline, from an initial height of 35cm above a tabletop.

a. Calculate the acceleration rate of the sphere as it rolls down the incline.

b. Use energy ideas to calculate the sphere's linear speed when it reaches the tabletop.

24. Two children balance on a 3m-long teeter-totter with the pivot point directly under the center of the teeter-totter. The child on the left end has a mass of 40kg and sits on the edge of her seat. The child on the right has a mass of 50kg and must scoot in some from the edge in order to balance. How far from the pivot point does the child on the right sit?

25. A 78cm-long uniform rod with rotational inertia of $0.15 kgm^2$ is initially hanging vertically from a pivot point at its top end. The rod is struck at its bottom end by a 200g ball of putty, moving at 4m/s to the left. If the putty sticks to the rod upon colliding with its, calculate the angular speed of the rod-putty combination directly after the collision.

UNIT 7: GRAVITATION & OSCILLATION

26. A 5kg rock is released from rest at a distance of 20m above the surface of a certain spherical asteroid. If the asteroid's mass is 7,500,000kg and its radius is 5.8m, how fast is the rock moving when it strikes the asteroid's surface?

27. For the same asteroid as discussed in #26, calculate its escape speed.

28. A 5kg rod is hung from a 10cm-long vertically-oriented spring, and stretches the spring an additional 3cm from equilibrium.

a. Calculate the k-value of the spring.

b. Now an additional identical spring is connected, so that the rod is supported by a spring at both ends. If it is set into oscillation, what is the period of its motion?

29. A spring (k=19.6N/m) is connected to a 3kg mass, making a horizontal mass-spring system. If the system is compressed 5cm and released from rest, find the following:

a. The maximum speed of the mass.

b. The x-location (distance from equilibrium) where the speed of the mass is 1/3 its maximum speed.

30. A 2kg sphere with a radius of 12cm is suspended from one end of a long thin rod that is free to pivot about an axis through its center. Calculate the period of its motion, if the rod has a mass of 800g and a length of 90cm.