

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY
School of Applied Natural Sciences
Department of Applied Physics
Work sheet I (Phys1101)

I. KINEMATICS

1. Car traveling at an initial speed v slides a distance d to a halt after its brakes lock. Assuming that the cars initial speed is instead $2v$ at the moment the brakes lock, estimate the distance it slides.
2. An object moves along the x axis according to the equation $x = (3t^2 + 2t - 3) \text{ m}$. Determine,
 - (a) the average speed between $t = 2 \text{ s}$ and $t = 3 \text{ s}$,
 - (b) the instantaneous speed at $t = 2 \text{ s}$ and at $t = 3 \text{ s}$,
 - (c) the average acceleration between $t = 2 \text{ s}$ and $t = 3 \text{ s}$,
 - (d) the instantaneous acceleration at $t = 2 \text{ s}$ and $t = 3 \text{ s}$.
3. A certain automobile manufacturer claims that its deluxe sports car will accelerate from rest to a speed of 42.0 m/s in 8.00 s
 - (a) Determine the average acceleration of the car.
 - (b) Assume that the car moves with constant acceleration. Find the distance the car travels in the first 8.00 s .
 - (c) What is the speed of the car 10.0 s after it begins its motion if it can continue to move with the same acceleration?
4. Suppose that the position vector for a particle is given as a function of time by $r = x(t)i + y(t)j$, with $x(t) = at + b$ and $y(t) = ct^2 + d$, where $a = 1.00 \text{ m/s}$, $b = 1.00 \text{ m}$, $c = 0.125 \text{ m/s}^2$ and $d = 1.00 \text{ m}$
 - (a) Calculate the average velocity during the time interval from $t = 2 \text{ s}$ to $t = 4 \text{ s}$.
 - (b) Determine the velocity and the speed at $t = 2 \text{ s}$.
 - (c) What is your average velocity ($\vec{v}_{avg}$) from the beginning of your drive to your arrival at the station?
5. A fish swimming in a horizontal plane has velocity $v_i = (4.00i + 1.00j) \text{ m/s}$ at a point in the ocean whose displacement from a certain rock is $r_i = (10.0i - 4.00j) \text{ m}$. After the fish swims with constant acceleration for 20.0 s , its velocity is $v = (20.0i - 5.00j) \text{ m/s}$.
 - (a) What are the components of the acceleration?
 - (b) What is the direction of the acceleration with respect to the unit vector i .
 - (c) Where is the fish at $t = 25.0 \text{ s}$ if it maintains its original acceleration and in what direction is it moving?
6. An object decelerates at a constant rate from an initial velocity of $-7i \text{ m/s}$ to a final velocity of $10i \text{ m/s}$.
 - (a) What is the objects acceleration if its displacement is $15i \text{ m}$?
 - (b) What would be the objects acceleration if the total distance it traveled were 15.0 m ?
7. A golf ball is hit off a tee at the edge of a cliff. Its x and y coordinates versus time are given by the following expressions:

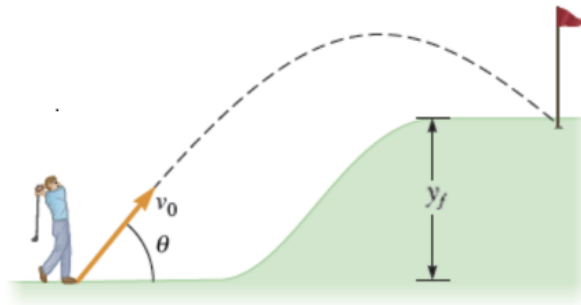
$$x = (18.0 \text{ m/s})t$$

and

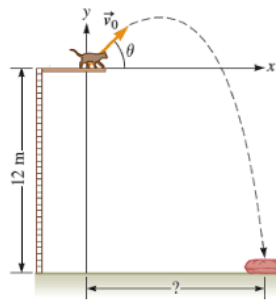
$$y = (4.00 \text{ m/s})t - (4.90 \text{ m/s}^2)t^2$$

- (a) Write a vector expression for the balls position as a function of time, using the unit vectors i and j . By taking derivatives of your results, write expressions for
- (b) the velocity vector as a function of time and
- (c) the acceleration vector as a function of time. Now use unit vector notation to write expressions for

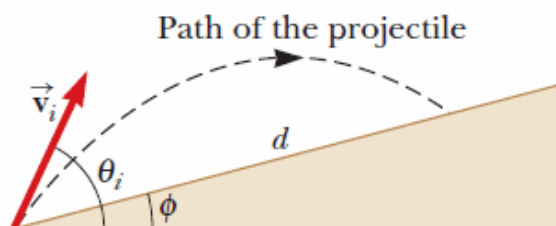
- (d) the position,
 (e) the velocity, and
 (f) the acceleration of the ball, all at $t = 3.00\text{ s}$.
8. A golfer hits his approach shot at an angle of 50.0° , giving the ball an initial speed of $v_0 = 38.2\text{ m/s}$ (as shown figure below). The ball lands on the elevated green, $y_f = 5.50\text{ m}$ above the initial position near the hole, and stops immediately.



- (a) How much time passed while the ball was in the air?
 (b) How far did the ball travel horizontally before landing?
 (c) What was the peak height reached by the ball?
9. An astronaut on a strange planet finds that she can jump a maximum horizontal distance of 15 m if her initial speed is 3.0 m/s . What is the acceleration due to gravity on the planet?
10. A projectile is fired in such a way that its horizontal range is equal to *three times* its maximum height. What is the angle of projection?
11. A circus cat has been trained to leap off a 12 m high platform and land on a pillow as shown below. The cat leaps off at $v_0 = 3.5\text{ m/s}$ and an angle $\theta = 25^\circ$
- (a) Where should the trainer place the pillow so that the cat lands safely?
 (b) What is the cat's velocity as she lands in the pillow?



12. A projectile is fired up an incline (incline angle ϕ) with an initial speed v_i at an angle θ with respect to the horizontal ($\theta > \phi$) as shown in figure below.

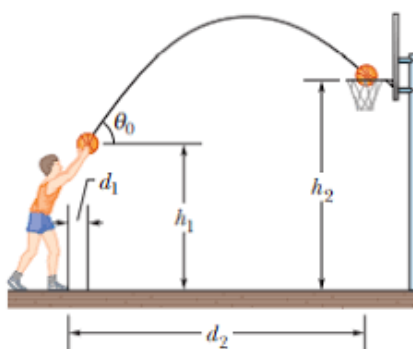


- (a) Show that the projectile travels a distance d up the incline, where

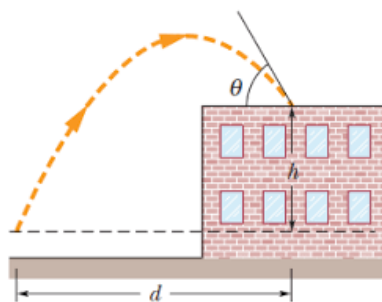
$$d = \frac{2v_i^2 \cos \theta \sin (\theta - \phi)}{g \cos^2 \phi}$$

- (b) For what value of θ is d a maximum, and what is that maximum value?

13. At what initial speed must the basketball player in Fig. below throw the ball, at an angle $\theta_0 = 55^\circ$ above the horizontal, to make the foul shot? The horizontal distances are $d_1 = 1.0$ ft and $d_2 = 14$ ft, and the heights are $h_1 = 7.0$ ft and $h_2 = 10$ ft



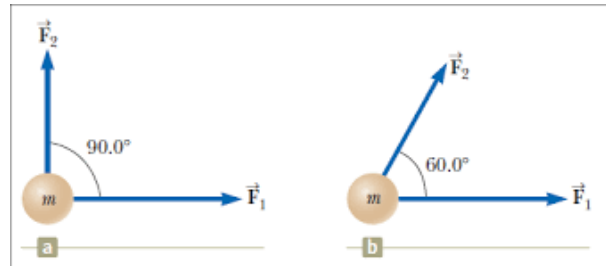
14. A projectile's launch speed is *five times* its speed at maximum height. Find launch angle θ .
15. In below fig. a ball is thrown up onto a roof, landing 4s later at height $h = 20.0$ m above the release level. The ball's path just before landing is angled at $\theta = 60^\circ$ with the roof.
- (a) Find the horizontal distance d it travels.
- (b) What are the magnitude and
- (c) angle (relative to the horizontal) of the ball's initial velocity?



II. DYNAMICS

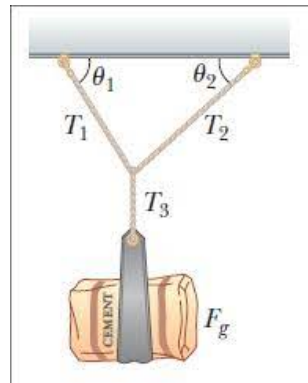
16. A particle's acceleration is $\vec{a} = (3.45\hat{i} - 1.84\hat{j})\text{m/s}^2$, and the total force exerted on the particle is $\vec{F} = (10.8\hat{i} - 5.76\hat{j})\text{N}$. what is the particle's mass?
17. A 2kg object is subjected to three forces that give it an acceleration $\vec{a} = -(8\text{m/s}^2)\hat{i} + (6\text{m/s}^2)\hat{j}$. If two of the three forces are $\vec{F}_1 = (30\text{N})\hat{i} + (16\text{N})\hat{j}$ and $\vec{F}_2 = -(12\text{N})\hat{i} + (8\text{N})\hat{j}$, find the third force.
18. Three forces, given by $F_1 = (-2\hat{i} + 2\hat{j})\text{N}$, $F_2 = (5\hat{i} - 3\hat{j})\text{N}$ and $F_3 = (-45\hat{i})\text{N}$, act on an object to give it an acceleration of magnitude 3.75 m/s^2 .
- (a) Write the acceleration vector.
- (b) What is the mass of the object?
- (c) If the object is initially at rest, what is its speed after 10 s?
- (d) What are the velocity components of the object after 10 s?

19. A force $F = (4xi + 3yj) \text{ N}$ acts on an object as the object moves from the origin to $x = 5\text{m}$ and $y = 7\text{m}$. Find the work done on the object by the force.
20. Two forces F_1 and F_2 act on a 5.00-kg mass. If F_1 20.0 N and F_2 15.0 N, find the accelerations in (a) and (b) of Figure

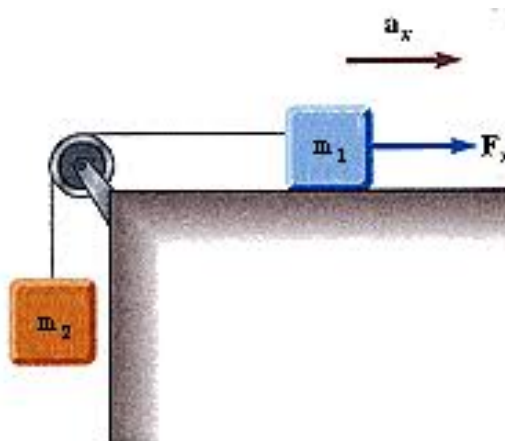


21. A bag of cement of weight F_g hangs from three wires as shown in Figure below. Two of the wires make angles θ_1 and θ_2 with the horizontal. If the system is in equilibrium, show that the tension in the left-hand wire is

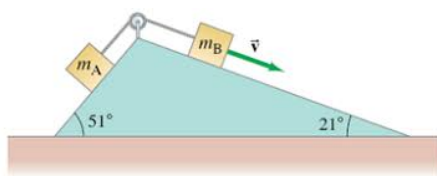
$$T_1 = F_g \cos \theta_2 / \sin(\theta_1 + \theta_2)$$



22. In the system shown in Figure below, a horizontal force F_x acts on the $m_1 = 8.00\text{kg}$ mass. The horizontal surface is frictionless.

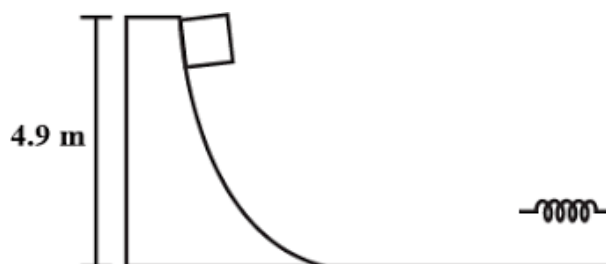


- (a) For what values of F_x does the $m_2 = 2.00\text{kg}$ mass accelerate upward?
- (b) For what values of F_x is the tension in the cord zero?
23. Two masses m_A and m_B are on inclines and are connected together by a string as shown in figure below. The coefficient of kinetic friction between each mass and its incline is $\mu_k = 0.3$. If m_A moves up, and m_B moves down, determine their acceleration. [Ignore masses of the (frictionless) pulley and the cord.]

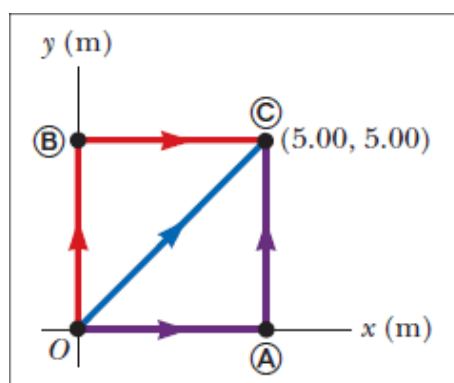


III. WORK AND ENERGY

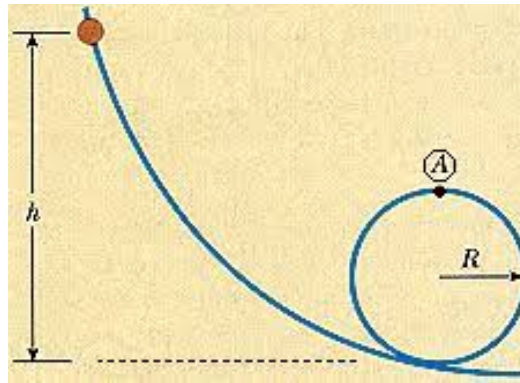
24. Figure below shows a smooth curved track terminating in a smooth horizontal part. A spring of spring constant 400 N/m is attached at one end to a wedge fixed rigidly with the horizontal part. A 40 g mass is released from rest at a height of 4.9 m on the curved track. Find the maximum compression of the spring



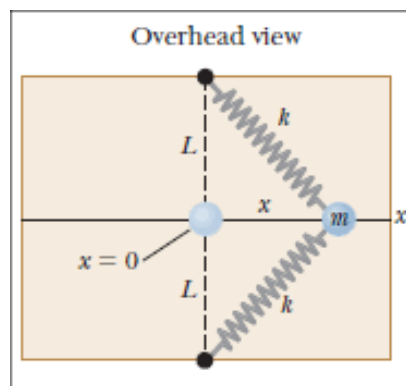
25. A force $F = (4xi + 3yj) \text{ N}$ acts on an object as the object moves from the origin to $x = 5 \text{ m}$ and $y = 7 \text{ m}$. Find the work done on the object by the force.
26. A force acting on a particle moving in the xy plane is given by $F = (2y i + x^2 j) \text{ N}$, where x and y are in meters. The particle moves from the origin to a final position having coordinates $x = 5 \text{ m}$ and $y = 5 \text{ m}$ as shown in figure below.



- (a) calculate the work done by the $\mathbf{F}$ along
 (i). OAC (ii). OBC (iii). OC
- (b) Is the given force being conservative or non-conservative force? Why?
27. A bead slides without friction around a loop-the-loop. The bead is released from a height $h = 3.5 R$ as shown in the below figure
- (a) What is its speed at point A ?
- (b) How large is the normal force on it if its mass is 5 g ?



28. A particle of mass 1.18 kg is attached between two identical springs on a horizontal frictionless tabletop. The springs have force constant k and each is initially unstressed.



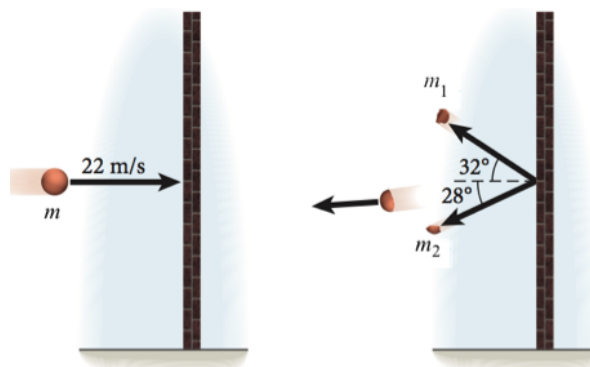
- (a) If the particle is pulled a distance x along a direction perpendicular to the initial configuration of the springs, as in figure above, show that the potential energy of the system is

$$U(x) = kx^2 + 2kL \left(L - \sqrt{x^2 + L^2} \right)$$

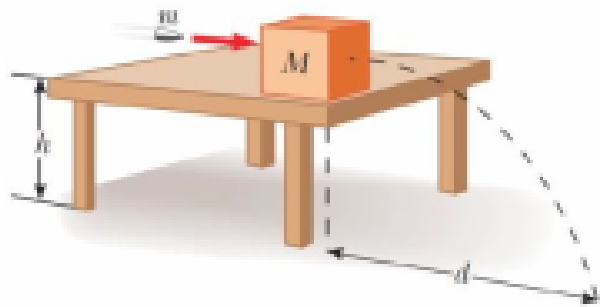
- (b) If the particle is pulled 0.5 m to the right and then released, what is its speed when it reaches the equilibrium point $x=0$?

IV. LINEAR MOMENTUM

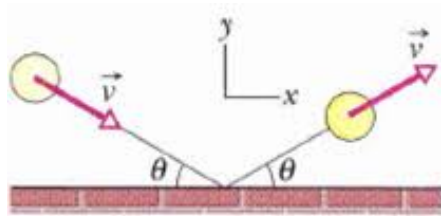
29. A 6 kg clay ball is thrown directly against a perpendicular brick wall at a velocity of 22 m/s and shatters into three pieces, which all fly backward, as shown in the figure. The wall exerts a force on the ball of 2640 N for 0.1 s . One piece of mass 2 kg travels backward at a velocity of 10 m/s and an angle of 32° above the horizontal. A second piece of mass 1 kg travels at a velocity of 8 m/s and an angle of 28° below the horizontal. What is the velocity of the third piece?



30. A bullet of mass m is fired with an initial speed of 500 m/s into a block of mass M initially at rest at the edge of a frictionless table of height h . The bullet remains in the block, and after impact the block lands a distance d from the bottom of the table. Determine the initial speed of the bullet and the distance d at which the block hits the floor.



31. In the overhead view of Fig. below, a 300 g ball with a speed v of 6.0 m/s strikes a wall at an angle θ of 30° and then rebounds with the same speed and angle. It is in contact with the wall for 10 ms . In unit vector notation, what are



- (a) the impulse on the ball from the wall and
 (b) the average force on the wall from the ball?
32. In Fig, below, block 1 of mass m_1 slides from rest along a frictionless ramp from height $h = 2.5 \text{ m}$ and then collides with stationary block 2, which has mass $m_2 = 2m_1$. After the collision, block 2 slides into a region where the coefficient of kinetic friction μ_k is 0.500 and comes to a stop in distance d within that region. What is the value of distance d if the collision is
- (a) elastic and
 (b) completely inelastic?

