Physics Final Review: Energy and Centripetal Force

1. A slingshot fires a stone horizontally from a tower which is 30 meters tall. The stone lands 80 meters from the base of the tower.
a) What was the speed of the rock when it left the slingshot?

b) What was the speed of the rock when it hit the ground?

2. A 5-gram coin is placed at the edge of a turntable which has a radius of 25 cm. The speed of the turntable is slowly increased until a point is reached where the coin slips of the turntable. The coefficient of friction between the coin and the surface of the turntable is 0.6. (Would this be static or kinetic fiction?)
a) Draw a force diagram for the forces on the coin while the turntable is spinning but before the coin slips off?

b) When the speed turntable reaches the point where coin slips off, what is the speed of the coin at that point?

c) When the coin reaches the speed you founding part b, what is the period T of the revolution? What is the rotation rate in rpm?

3. In the spin cycle of a washing machine, the clothes must have an acceleration of 75 m/sec^2 to have the water squeezed out of them. The radius of the basket is 40 cm. What is the spin rate of the basket in rpm?

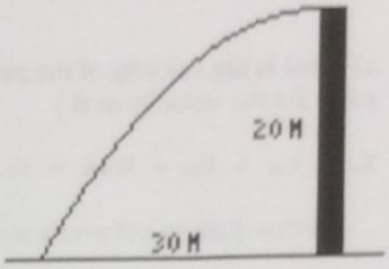
4. A pitcher throws a ball horizontally at 42 m/sec. What distance does the ball drop from its original height by the time it crosses the plate 18 meters away?

5. The planet Mars have two very small moons. One of the moons, named Phobos, has a radius of 11.1 km and mass of 1.072×10^{16} kg. The gravity on the surface of that moon is so weak that an astronaut would be able to throw a rock into orbit around the planet.
a) Find the acceleration of gravity on the surface of Phobos.

b) If an astronaut were to throw a 1-kg rock into orbit around the planet such that the rock would orbit the planet just a few feet above the ground, what would be the speed of the rock?

c) If the planet were perfectly round, the rock would return to the spot from which it was initially thrown. What would be the time it would take for the rock to return to its original spot?

6. You are standing 30 meters away from the base of a tower which is 20 meters tall. You wish to throw a ball to a person at the top of the tower so that he catches it at the top of its trajectory. [There is a 20-m vertical distance between your hand and the hand of the person catching the ball.]
(a) What is the time the ball will be in the air? (b) What is the initial vertical velocity v_{oy} of the ball? (c) What is the initial horizontal velocity v_{ox} of the ball? (d) What is the initial speed of the ball when thrown? (e) At what angle above the horizontal is the ball initially thrown?



7. A golf ball is hit with an initial speed $\mathbf{v}_o = 60$ m/s at an angle of 53°.

a) Calculate v_{ox} and v_{oy}.

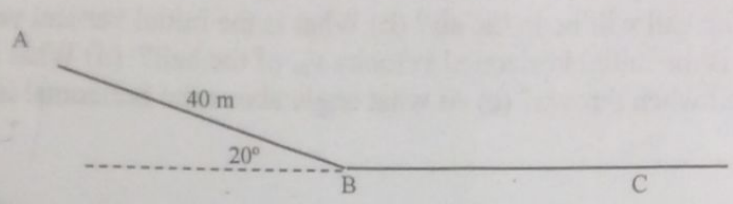
b) What are v_x and v_y two seconds after the ball is hit?

c) Assuming the ball lands at the same altitude from which it is hit, what horizontal distance does the ball travel?

d) What is the maximum height reached by the ball?

e) What is the velocity of the ball at the top of its trajectory?

8. A 60-kg person, initially at rest, slides down a frictionless snowy hill. The length of the hill is 40 m and the angle of the hill is 20°. At the bottom of the hill (at point B) the person encounters wet grass. He slides along the wet grass until he comes to a stop. The coefficient of friction between the wet grass and the seat of his pants is 0.3.



a) What is the velocity of the person at point at the bottom of the hill? (Fill in the bar chart then solve for the velocity at B.)

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

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b) The person slides along the wet grass until he stops at point C. Fill in the bar chart and solve for the distance he slides between B and C.

$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + U_{int}$

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9. A 500 gram toy rocket sits at rest on a launch pad ($y = 0$.) The fuel in the rocket contains 400 J of chemical potential energy.

The rocket fuel is ignited sending the rocket vertically upward. After the fuel is all used up, the rocket continues upward.

a) Show an energy bar chart where the initial state is the rocket on the launch pad and the final state is the rocket at some height above the ground, moving upward but out of fuel. Ignore heat loss due to friction.

$K_o + U_{go} + U_{chem\,o} + \text{Work} = K_f + U_{gf} + U_{chem\,f} + U_{int}$

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b) Find the velocity of the rocket at a point where the rocket is 50 m above the ground, moving upward and out of fuel.

c) More realistically, there will be some air resistance on the rocket resulting in heat loss. Suppose that by the time the rocket reaches a height of 50 m the heat loss due to air resistance is 10% of the original chemical potential energy that was in the fuel. Find the velocity of the rocket at a height of 50 m under these circumstances. (First fill in the bar chart.)

$K_o + U_{go} + U_{chem\,o} + \text{Work} = K_f + U_{gf} + U_{chem\,f} + U_{int}$

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10. A man pushes a car with 70 pounds (300 N) of force.

a) How much work (in joules) does he do on the car to push the car 10 feet (3 meters)?

b) How much work (in joules) does he do on the car to push the car 100 feet?

c) If he can push the car at 1 mph (.5 m/s) while pushing the car with 70 pounds of force, how many seconds does it take him to push the car 100 feet?

d) How many watts of power is he generating while pushing the car? What fraction of a horsepower is he generating?

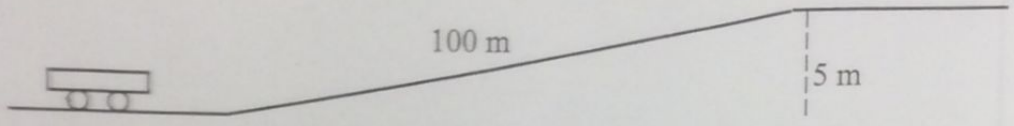
e) If his body is 1/6 efficient, how many kilocalories does he have to consume to push the car 100 feet?

f) At what rate is his body consuming energy in kcal/hr?

11. A 1500-kg car is traveling at 55 mph (25 m/sec). The car comes to an exit ramp that slopes upward.

The ramp is 100 m long and increases 5 m in altitude over the length of the ramp. There is a force of friction of 500 N against the car as it travels up the ramp.

What is the speed of the car at the top of the ramp?



$K_o + U_{go} + U_{so} + \text{Work} = K_f + U_{gf} + U_{sf} + \text{Heat}$

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12. An object is launched from the ground and returns to the ground. It is in the air a total time of 5 seconds and travels horizontal distance of 120 meters.

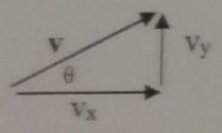
a) Determine the initial vertical velocity.

$v_{oy} =$

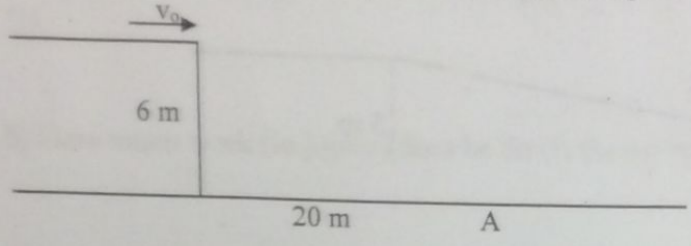
b) Determine the initial horizontal velocity.

$v_{ox} =$

c) Determine the launch speed and launch angle.



13. A person runs horizontally off of a level ledge and lands at point A 20 meters away.
a) How long will the person be in the air?
b) What is his initial speed v_o when he leaves the ledge?
c) What are the x and y components of his velocity when he lands at point A? (That is, what are v_x and v_y?)
d) **Draw the vector components v_x and v_y when he lands. Draw the velocity vector when he lands.** What is his impact speed when he lands at point A?



14. At your job, you spend time lifting boxes from the floor to a shelf that is 3 feet (0.9 m) above the floor. At the end of 15 minutes, you have lifted 90 boxes.

For each box that you lift, you are essentially lifting 100 lbs. (45 kg) since you lift part of your body weight as well as the box.

1 kcal = 4200 J

a) How many joules of energy are required to lift each box?

b) How many kcal does your body have to consume in order to lift 90 boxes (assuming 1/6 efficiency)?

c) At what rate does your body burn energy in terms of kcal/hr?

15. A rubber band when stretched behaves like a spring. A particular rubber band has an unstretched length of 20 cm. When a 1 kg weight is attached to the rubber band, it stretches to a total length of 45 cm. What is the spring constant of the rubber band?

16. That same rubber band is now stretched horizontally to a total length of 55 cm. It is then released and shot like we did in the experiment in class. What is the velocity of the rubber band immediately after being shot? (The mass of the rubber band is 4 grams.)

17.) Tarzan attempts to swing from one tree to another on a vine. The vine length is 15m and his speed at the bottom of the swinging motion is 15 m/s.

A.) Calculate the centripetal force required to keep the circular path.

B.) Calculate the centripetal acceleration of Tarzan

C.) Tarzan has a maximum grip strength of 1500 N. What is the maximum velocity he can swing and still hang on to the vine?