

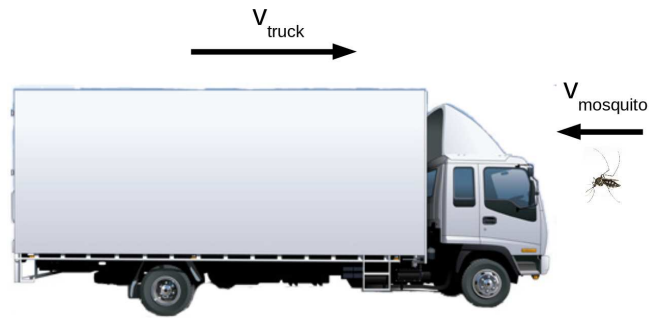
Physics 3210, Spring 2018
Exam #1

Name:
Signature:
UID:

Please read the following before continuing:

- Show all work in answering the following questions. Partial credit may be given for problems involving calculations.
- Be sure that your final answer is clearly indicated, for example by drawing a box around it.
- Be sure that your cellphone is turned off.
- Your signature above indicates that you have neither given nor received unauthorized assistance on any part of this exam.
- Thanks, and good luck!

1. (4 pts) A large truck speeding down the highway strikes a mosquito.



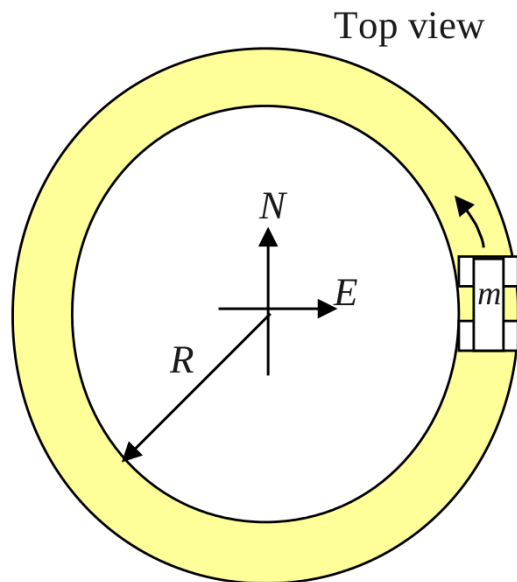
- (a) (2) Does the truck or the mosquito experience a force of greater magnitude during the collision? Explain.

- (b) (2) Indicate with an arrow on the figure the direction of the truck's *acceleration* during the collision.

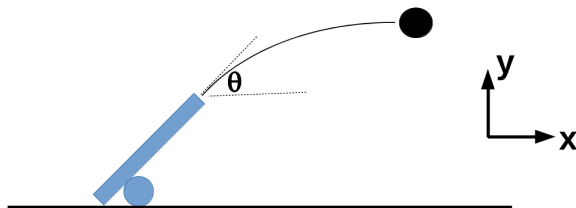
2. (4 pts) A hockey puck is sliding on wet ice with constant velocity to the right. Assuming there is no friction, draw a complete free body diagram for the hockey puck indicating all forces.



3. (4 pts) A car is driving on a circular track as shown in the figure below. At the time shown, the driver steps on brakes so that the car's tangential speed is decreasing. On the figure below, sketch the direction of the net frictional force being applied by the car's wheels on the track. The wheels are rolling without slipping.



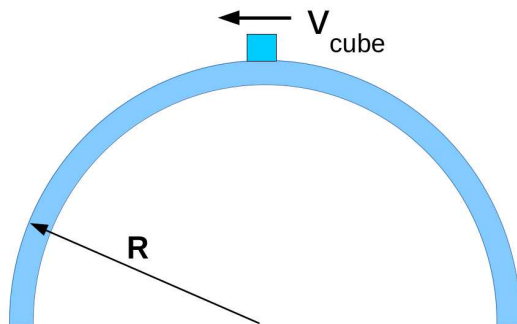
4. (16 pts) A cannon fires a projectile with initial speed v at an angle of θ with respect to horizontal. The projectile flies under the influence of uniform gravity, before returning to Earth. Assume air resistance is negligible.



Indicate with a “T” or “F” whether the following statements are true or false while the projectile is in flight:

- (a) _____ The y component of the projectile's velocity is never zero.
- (b) _____ The horizontal (x) component of the projectile's velocity remains constant.
- (c) _____ The acceleration of the projectile remains constant during its upward flight.
- (d) _____ The vertical (y) component of the projectile's velocity remains constant.
- (e) _____ The horizontal acceleration of the projectile is zero.
- (f) _____ The vertical acceleration of the projectile is zero.
- (g) _____ The x component of the projectile's velocity is never zero.
- (h) _____ The minimum speed of the projectile during its flight is equal to $v \sin \theta$.

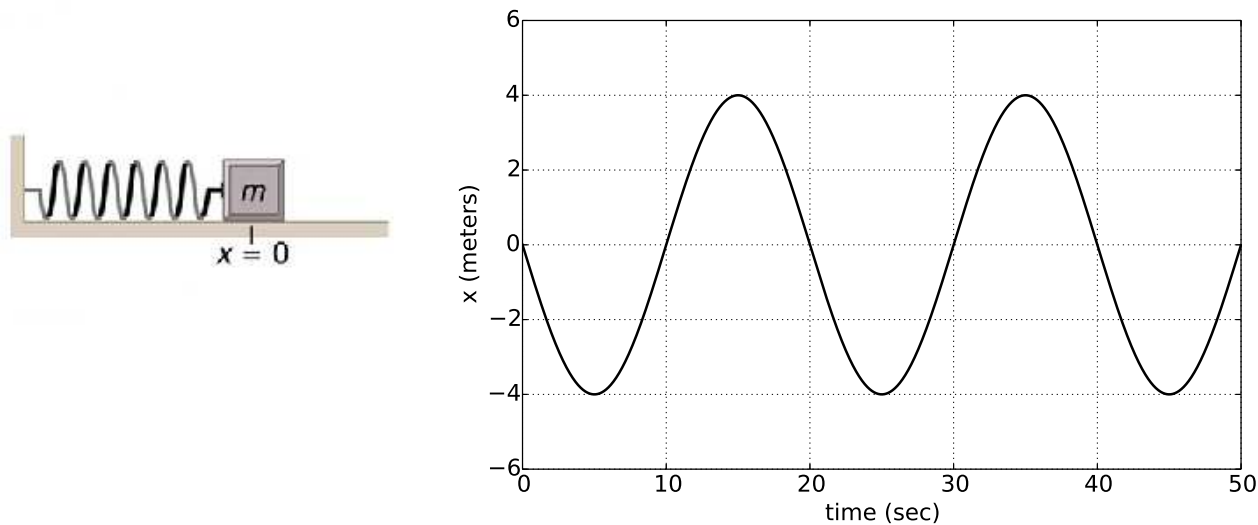
5. (10 pts) An ice cube of mass m is sliding without friction on an inverted spherical bowl of radius R . Calculate the maximum value of the cube's speed v_{cube} at the instant shown, such that the cube does not fly off the bowl. Give your answer in terms of the variables m , R , and the acceleration due to gravity g . *Hint: What is the value of the normal force just before the cube leaves the bowl?*



6. (18 pts) A *simple harmonic oscillator* consists of a block of mass m sliding on a frictionless surface, under the influence of a massless spring. The force exerted by the spring on the block is given by

$$\vec{F} = -kx \hat{x}$$

where x is the coordinate of the block relative to the equilibrium position $x = 0$. A graph of the block's position versus time is shown below.



Answer the following questions.

- (a) (2) What is the period of oscillation of the block?
- (b) (3) If $m = 1.2$ kg, what is the value of the spring constant k ?
- (c) (2) What is the block's position at $t = 0$ sec?
- (d) (2) What is the first time at which the block's speed is zero?

Problem continued on the following page.

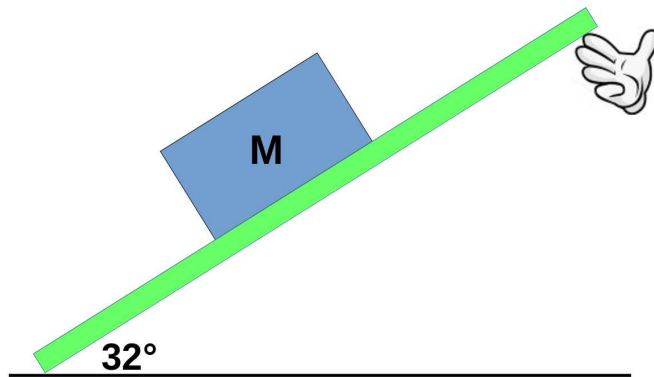
(e) (3) What is the block's acceleration at $t = 60$ sec? (I know ... its not on the graph!)

(f) (6) A general solution for the motion of the block is given by

$$x(t) = A \cos(\omega t + \phi)$$

where A and ϕ are constants of integration. Determine A and ϕ for the particular motion shown in the graph.

7. (12 pts) A block of mass $m = 0.75$ kg sits at rest on a smooth (but not frictionless) surface. The ramp is slowly tilted by hand until it makes an angle of 32° with respect to horizontal, at which point the block begins to slide.



- (a) (6) Draw a *free body diagram* of the block just before it starts to slide.
- (b) (6) Calculate the *coefficient of static friction* μ_s between the block and the ramp.

8. (16 pts) An satellite orbits the Earth at a constant distance R_o from the center of the Earth, at a constant speed v .

Useful Constants:

$$G = 6.673 \times 10^{-11} \text{ m}^3/(\text{kg s}^2)$$

$$M_E = 5.972 \times 10^{24} \text{ kg}$$

$$R_E = 6.371 \times 10^6 \text{ m}$$

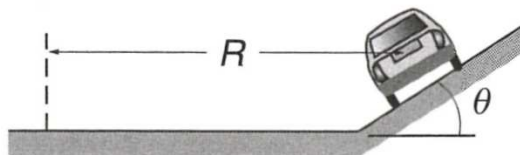
- (a) (4) Write down the general expression for the velocity vector \vec{v} and acceleration vector \vec{a} in polar coordinates.

- (b) (6) Simplify the expressions for \vec{v} and \vec{a} , for the satellite's uniform circular motion.

Problem continued on the following page.

- (c) (6) Use the above to evaluate the velocity of the satellite as a function of G , M_E , and R_o . Derive a numerical answer (in kilometers/second) for the case $R_o = 2R_E$.

9. (16 pts) A particular turn on a highway has radius is $R = 100$ m. The road is banked at an angle θ , and the coefficient of friction between the wheels of the car and the road is μ_s .



- (a) (6) Draw a complete *free body diagram* of a car on this curve, assuming the car is just about to start sliding off the road to the right.

Problem continued on the following page.

- (b) (10) If $\mu_s = 0.10$, $\theta = 20^\circ$, and $R = 100$ m, what should the speed limit be so that cars will not slide off the road?