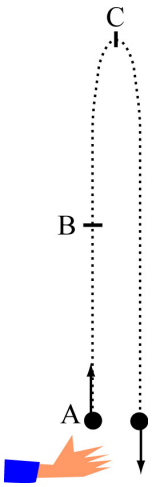
PHY 101 Name ___Solution Key_____
Take home exam #1

Show and explain your work and hand in the answers on the exam sheet.

1/ The Earth rotates at a constant rate, with a period of 24 hours. What force (or torque) causes the rotation of the Earth? Explain.

No force (or torque) causes the rotation of the Earth. The Earth continues to rotate because inertia (Newton's first law of motion). [2 points]

2/ Throw a baseball ***straight up***, as shown. The speed when it leaves your hand (at point A) is v_0 = 14 m/s. Neglect the force of air resistance.



Useful equations:

$$v = v_0 - gt \quad \text{and} \quad y = v_0 t - \frac{1}{2} g t^2$$

(a) Calculate the speed at point B (half way to the top.)

$$v_b = \sqrt{v_0^2 - 2g(y_c/2)} = 9.90 \text{ m/s}$$

Note: use the result of part (c). [1 point]

(b) What is the speed at point C (the top)?

At the top, v = 0. The ball in instantaneously at rest. [1 point]

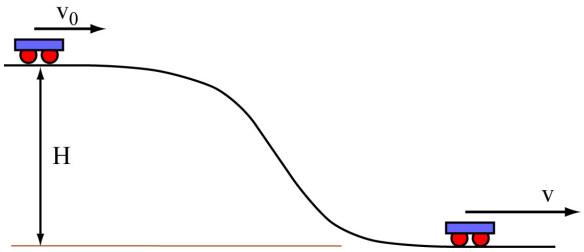
(c) Calculate the height at C, i.e., the distance above A.

$$y_c = \frac{v_0^2}{2g} = 9.99 \text{ m}$$ **[1 point]**

(d) What is the force on the ball at C? Give both the magnitude and direction. If the magnitude is 0, explain why.

The only force on the ball at C is the force of gravity. The magnitude is mg (m = mass of the ball). The direction is downward. [1 point]

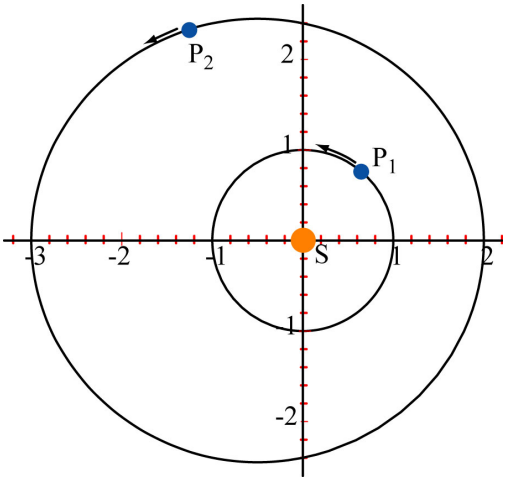
3/ Consider the roller coaster car. At the top of the slope the speed is v_0. The height of the slope is H. Derive a formula for the speed v at the bottom of the slope, neglecting air resistance.



Derive the equation from conservation of energy. The result is

$$v = \sqrt{v_0^2 + 2gH}$$ **[2 points]**

4/ A star S has two small planets P_1 and P_2, as shown in the figure. The period of revolution of P_1 is 1 year.



(a) Calculate the period of revolution of P_2.

The semimajor axis of the orbit of P2 is $a_2 = 2.5$.
Use Kepler's third law: T^2 is proportional to a^3.

$$T_2 = T_1\left(\frac{a_2}{a_1}\right)^{3/2} = 2.5^{3/2} = 3.95 \text{ years}$$

(b) Calculate the eccentricity of the orbit of P_2.

The sun is at one focal point, at (x,y)=(0,0). The other focal point is located at (x,y)=(-1,0). The distance between the focal points is 1. The length of the major axis is 5. Thus the eccentricity is 1/5 = 0.2.