

EXAM II Physics 218

Name.....Section Number.....

USEFUL INFORMATION

$$\text{If } f(x) = kx^n \cdot \quad \frac{df}{dx} = nkx^{n-1}$$

$$\text{If } f(x) = kx^n \quad \int_A^B f(x)dx = \frac{1}{n+1}k(B^{n+1} - A^{n+1})$$

$$\text{If } f(x) = kx^n \quad \int f(x)dx = \frac{1}{n+1}kx^{n+1} + C$$

$$\int_{\vec{r}_1}^{\vec{r}_2} \vec{F}_{tot} \cdot d\vec{r} = \frac{1}{2}mv^2(\vec{r}_2) - \frac{1}{2}mv^2(\vec{r}_1)$$

If  $\vec{F}$  is conservative:

$$\int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{r} = -[U(\vec{r}_2) - U(\vec{r}_1)]$$

and

$$F_x = -\frac{\partial U}{\partial x} \quad F_y = -\frac{\partial U}{\partial y}$$

DO NOT WASTE TIME DOING ARITHMETIC

1.

2.

3.

4.

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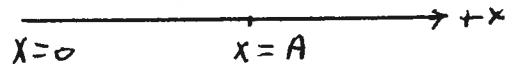
1. (25 points) This is a one-dimensional problem. An object of mass  $m$  is acted upon by a force given by

$$F_x = -(c_1x^2 - c_2x)$$

where  $c_1$  and  $c_2$  are positive constants.

- a. Determine whether or not this force is conservative.

- b. If the object is placed at the point  $x = A$  and given a velocity of magnitude  $v_1$  in the positive  $x$  direction, at what point would the object stop moving in the positive  $x$  direction and begin moving in the negative  $x$  direction, assuming the above force is the only force acting on the object? (No algebra please!)



- c. Find the object's kinetic energy as a function of  $x$ , given the conditions in b. above.

2. (25 points) A small block of mass,  $m_1$ , is placed on top of a larger block mass,  $m_2$ , and the top block is connected to a third block,  $m_3$ , by a massless, unstretchable string which goes over a frictionless pulley. (The pulley therefore changes the direction of the force exerted by the string but not its magnitude.) The coefficient of friction between blocks is  $\mu$  and the surface that the large block is on is frictionless. Assume the masses are such that the third block moves down and that the other blocks move together, in other words there is no slipping.

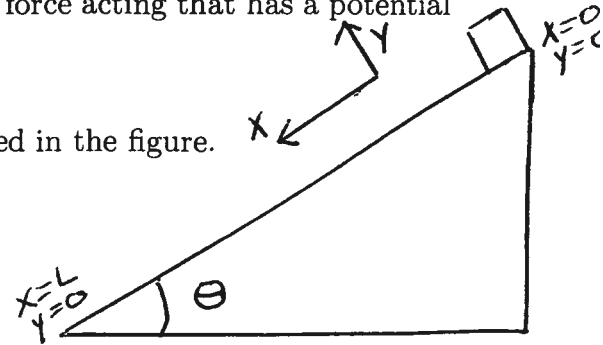


- a. Isolate  $m_1$ , draw the free body diagram for it and apply Newton's Second Law.
- b. Isolate  $m_2$ , draw the free body diagram for it and apply Newton's Second Law.
- c. Isolate  $m_3$ , draw the free body diagram for it and apply Newton's Second Law.
- e. What is the acceleration of  $m_3$  ?
- e. What is the largest value that the acceleration of  $m_3$  can have before slipping occurs?

3. A block of mass  $m$  slides down an inclined plane, starting from rest. In addition to the other forces acting on the body there is a mysterious force acting that has a potential energy function given by

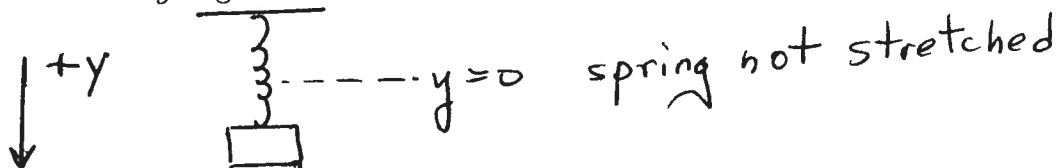
$$U(x, y) = \beta(x^2 + y^2)$$

where  $\beta$  is a known constant and  $x$  and  $y$  are defined in the figure.



- Find  $\vec{F}_{myst}$  the mysterious force in terms of  $x, y$ , and  $\beta$ .
- Find the velocity of the block when it reaches the bottom of the plane with no friction.
- Find the velocity of the block when it reaches the bottom if there were a coefficient of friction between the block and the plane  $\mu$ .

4. (25 points) In a famous Physics 218 experiment it was discovered that a real spring doesn't totally follow Hooke's Law. The force exerted by the spring is found to be a linear function of the amount stretched, as Hooke's Law says. However, instead of having  $F_y = -ky$  where  $y$  is the amount stretched, the actual force exerted by the spring is approximately given by  $F_y = -(ky + b)$ . Here  $k$  and  $b$  are known constants. Thus if the spring is vertical there will be no stretching of the spring when a mass  $m$  is hung from it unless  $mg$  is greater than  $b$ .



- a. Given this force, with  $b$  known, determine the equilibrium amount the spring will be stretched if a mass with  $mg > b$  is suspended from it. (Call this  $y_{eq}$  as in the lab.)
- b. Find the maximum value of the spring's extension if such a mass were released from rest from  $y = 0$ , the point where the spring is not stretched. How is this distance related to  $y_{eq}$ .
- c. Find the maximum value of the mass's kinetic energy if it were released from rest from the point  $y = 0$ . (Not too much algebra please.)