 Name: KEY

Test: *Work & Energy*

2013

Equations and Constants:

$\bar{v} = \frac{\Delta x}{\Delta t}$ $v = \frac{dx}{dt}$ $\bar{a} = \frac{\Delta v}{\Delta t}$ $a = \frac{dv}{dt}$ $\bar{v} = \frac{1}{2}(v_i + v_f)$ $|g| = 10\ \text{m/s}^2$

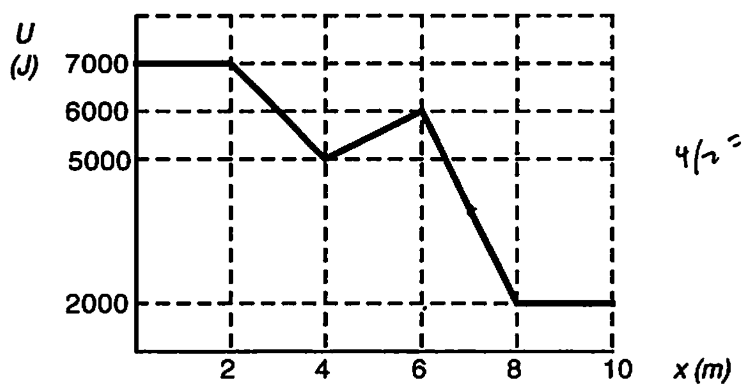
$x = \frac{1}{2}at^2 + v_i t + x_i$ $v = at + v_i$ $v_f^2 = v_i^2 + 2a\Delta x$ $R = \frac{v^2 \sin 2\theta}{g}$ $a_c = \frac{v^2}{r}$

$\sum F = ma$ $w = mg$ $w_\perp = mg\cos\theta$ $w_\parallel = mg\sin\theta$ $f = \mu N$ $F = -\frac{dU}{dx}$

$W = Fd\cos\theta$ $W = \int \vec{F} \cdot d\vec{x}$ $K = \frac{1}{2}mv^2$ $P = \frac{dW}{dt}$ $P = Fv$ $U_{gravity} = mgh$ $U_{spring} = \frac{1}{2}kx^2$

Multiple Choice: *Choose the letter of the best answer. 3 points each.*
Unless otherwise stated, ignore the effects of air resistance. $|g| = 10\ m/s^2$
USE CAPITAL LETTERS!

Problems 1 to 3 refer to the following:
The potential energy of an object in a force field as a function of position is given by the graph shown:



4/2 = 2000

1. B What is the force on the object at x = 7 meters?
   a. 571 N. b. 2000 N c. 3500 N. d. 4000 N. e. None of those.

2. A At which of the following positions would the object be in a neutral equilibirum?
   a. x = 1 m. b. x = 4 m. c. x = 5 m. d. x = 6 m. e. x = 7 m.

3. E What is the maximum kinetic energy the object could have and remain oscillating?
   a. 7000 J. b. 6000 J. c. 5000 J. d. 2000 J. e. 1000 J.

4. C Imagine you have a kinetic energy of 2000 J. How much work would it take to double your speed?
   a. 2000 J. b. 4000 J. c. 6000 J. d. 8000 J.
   e. Need to know your mass and speed to answer the question.

   = ×4 K = 8000 K
   = +6000 J

5. D What is a conservative force?
   a. A force that only does negative work.
   b. A force that only does positive work.
   c. A force that can cause an object to go back to its starting point.
   d. A force that does no net work on an object if it ends at its starting point.
   e. Ted Cruz.

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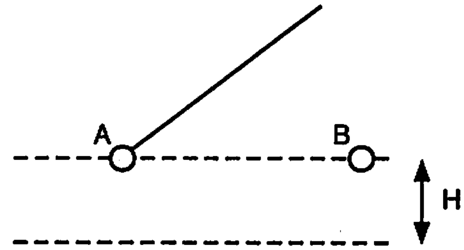
Problems 6 and 7 refer to the following:

Object A is a pendulum pulled back so that it falls a distance H. Object B is an identical mass held at the same initial height as A. They are both released at the same time.



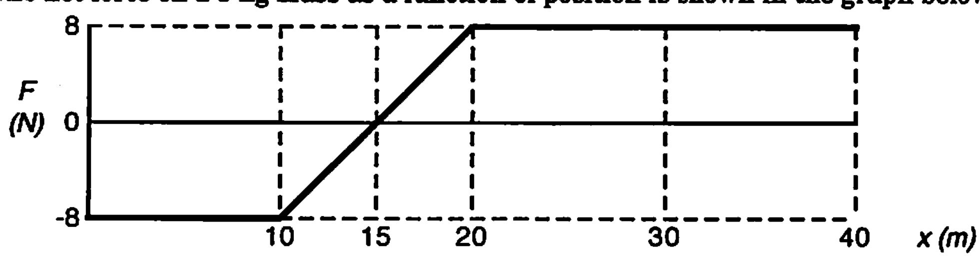
6. C Which object will be going faster after falling through the height H?
   a. A. b. B. c. they have the same speed.
   d. it could be either A or B, depending on the initial angle of the pendulum.

7. B Which object will take less time to fall distance H?
   a. A. b. B. c. they take the same time.
   d. it could be either A or B, depending on the initial angle of the pendulum.

8. A Imagine getting a heavy box up a height of 2 meters by either lifting it straight up or pushing it up a ramp that was 6 meters long. It would take more work to push it up the ramp because
   I. Friction will do some work on the box.
   II. Because the normal force will do some work on the box.
   a. I only. b. II only. c. both I & II. d. none of those answers are right.

Problems 9 and 10 refer to the following:

The net force on a 3 kg mass as a function of position is shown in the graph below:



9. A What is the total work done on the object for the entire region shown?
   a. 80 J. b. 133 J. c. 180 J. d. 320 J. e. 400 J.

10. C Assuming the object moved from x = 0 to x = 40, where would it be going the slowest?
    a. x = 0 m. b. x = 10 m. c. x = 15 m. d. x = 20 m. e. x = 40 m.

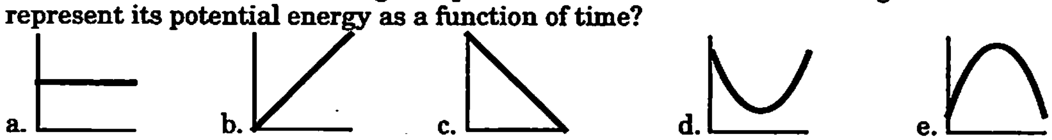
Problems 11 and 12 refer to the following:

Charlie lifts 50 kg 4 meters in 10 seconds. Kristen lifts 25 kg 8 meters in 8 seconds.

11. C Who did more work?
    a. Charlie. b. Kristen. c. they were the same. d. impossible to tell.

12. B Who exerted more power?
    a. Charlie. b. Kristen. c. they were the same. d. impossible to tell.

13. E A ball is tossed in the air and goes up and down. Which of the following would best represent its potential energy as a function of time?



14. A An object of mass 1 kg is whirled around in a horizontal circle of radius 0.5 m and at a constant speed of 2 m/s. The work done on the object during one revolution is:
    a. 0 J. b. 1 J. c. 2 J. d. 4 J. e. 16 J.

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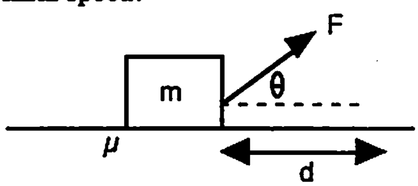
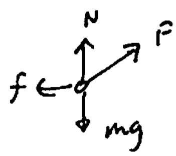
Problem Solving: *Show all work.*
Use work/energy principles! No energy = -6

15. **A mass (m = 6 kg) is being pulled by a force (F = 50 N, θ = 35°) across a floor with a coefficient of friction (μ = 0.4). It has an initial speed of 5 m/s and is pulled a distance of 7 meters. What is its final speed?**





$N = mg - F\sin\theta$

$\frac{1}{2}mv_i^2 - fd + Fd\cos\theta = \frac{1}{2}mv_f^2$

$\frac{1}{2}mv_i^2 - \mu(mg - F\sin\theta)d + Fd\cos\theta = \frac{1}{2}mv_f^2$

$\frac{1}{2}(6)(5)^2 - (.4)[(6)(10) - (50)\sin 35]d + (50)\cos 35\, d = \frac{1}{2}(6)v_f^2$

$(.4)[60 - 28.7]$ = 31.3

$75 - (12.53)(7) +$

$75 - 87.7 + 286.7 = 3v_f^2$

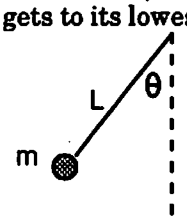
$274 = 3v_f^2$

$v_f^2 = 91.3$

$v_f = 9.56$ m/s

for FBD
No $Fd\cos\theta$ -5
No μN -3
No $N = mg$
No d -3

16. **A 1.5 meter, 0.25 kg pendulum is pulled back an angle ø from the vertical and released. When it gets to its lowest position, the tension in the string is 3.5 N. What was the initial angle ø?**



↑T ↓mg

$T - mg = \frac{mv^2}{L}$ → $v^2 = \frac{L(T - mg)}{m}$

$3.5 - 2.5 = \frac{(.25)v^2}{1.5}$

$v^2 = 6$

$v = 2.45$

fd -6

$mgh = \frac{1}{2}mv^2$

$mg(L - L\cos\theta) = \frac{1}{2}mv^2$

$gL - gL\cos\theta = \frac{1}{2}v^2$

$1 - \cos\theta = \frac{v^2}{2gL}$

$\cos\theta = 1 - \frac{v^2}{2gL}$

$gh = \frac{1}{2}v^2$

$10h = 3$

$h = .3$

$\cos\theta = 1 - \frac{(6)}{2(10)(1.5)} = .8$

$\theta = 36.9°$

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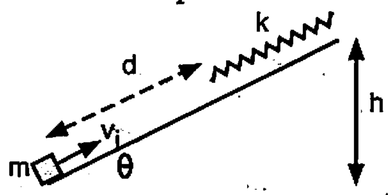
17. A 2.3 kg object is launched with a speed of 7 m/s up a frictionless track of base angle 35°. It slides up a distance of 2 meters and then hits a spring, causing the spring to compress a distance of x. The spring constant is 300 N/m. What is the height of the object when the spring is at its maximum compression?



$$E_i = E_f$$

$$\tfrac{1}{2}mv_i^2 = mgh + \tfrac{1}{2}kx^2$$

$$\tfrac{1}{2}mv^2 = mg(d+x)\sin\theta + \tfrac{1}{2}kx^2$$

$$\tfrac{1}{2}(2.3)(7)^2 = (2.3)(10)(2+x)(\sin 35) + \tfrac{1}{2}(300)x^2$$

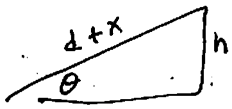
$$56.35 = 26.38 + 13.19x + 150x^2$$

$$150x^2 + 13.19x - 29.97 = 0$$

$$x = \frac{-13.19 \pm \sqrt{(13.19)^2 - 4(150)(-29.97)}}{2(150)}$$

$$x = \frac{-13.19 \pm 134.7}{300} \quad (+\ \text{root})$$

$$x = \frac{121.55}{300} = .41\ \text{m}$$



$$\sin\theta = \frac{h}{d+x}$$

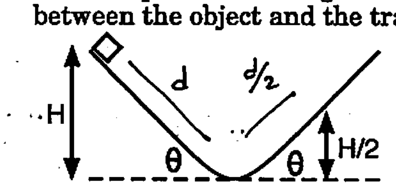
$$h = (d+x)\sin\theta$$

$$\therefore\ h = (2+.41)\sin 35$$

$$h = 1.38\ \text{m}$$

no mgh −5

18. An object is released from rest at a height H on a symmetrical track, with base angles ø. It travels up to a final height of H/2 on the opposite side. What was the coefficient of friction between the object and the track?



$$E_i - fd = E_f$$

$$mgH - \mu mg\cos\theta\, d - \mu mg\cos\theta\,\frac{d}{2} = mg\frac{H}{2}$$

$$H - \mu\cos\theta\, d - \mu\cos\theta\,\frac{d}{2} = \frac{H}{2}$$

$$\frac{H}{2} = \mu\cos\theta\,\frac{3d}{2}$$

$$\mu\cos\theta = \frac{H}{3d}$$

$$\frac{H}{d} = \sin\theta\ ! \quad \left(d = \frac{H}{\sin\theta}\right)$$

$$\mu\cos\theta = \frac{\sin\theta}{3}$$

$$\mu = \tfrac{1}{3}\tan\theta$$

so total D = $\frac{H}{\sin\theta} + \frac{H}{2\sin\theta} = \frac{3H}{2\sin\theta}$

has "d" −4