807 AP Physics Schmidt

Name ______________________

U4H5 Unit 4: Power – and additional problems

1. The loaded cab of an elevator has a mass of 3.0×10^3 kg and moves 200 m up the shaft in 20 s at constant speed. At what average rate does the cable do work on the cab? (300,000 J/s or Watts (W))

2. A swimmer moves through the water at a speed of 0.22 m/s. The drag force opposing this motion is 110 N. What power does the swimmer develop? (24.2 W)

3. A gardener pushes a 12kg lawnmower whose handle is tilted up 37° above the horizontal. The lawnmower's coefficient of rolling friction is 0.15. How much power does the gardener have to supply to push the lawnmower at a constant speed of 1.2 m/s? (Assume his push is parallel to the handle) (24W)

4. You've taken a summer job at a water park. In one stunt, a water skier is going to glide up the 2 m high frictionless ramp shown below, then sail over a 5 m wide tank filled with hungry sharks. You will be driving the boat that pulls her to the ramp just as you veer away. What minimum speed must you have as you reach the ramp in order for her to live to do this again tomorrow? (10 m/s)

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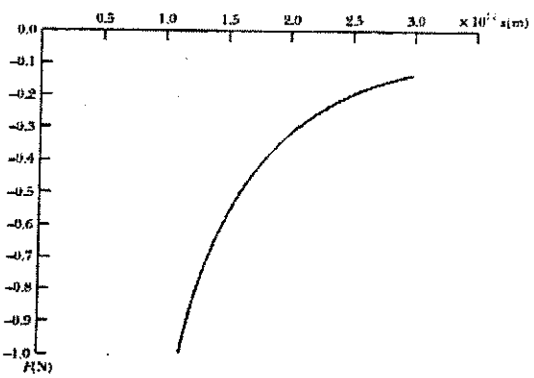
5. The spring shown below has a spring constant of 1000 N/m. It is compressed 15 cm, then launches a 200g block. The horizontal surface is frictionless, but the block's coefficient of kinetic friction on the incline is 0.2. What distance d does the block sail through the air? (6.45 m)

6. An interplanetary probe is attracted to the Sun by a force of magnitude $F = -1.3 \times 10^{22}/x^2$ where x is the distance measured outward from the Sun to the probe. The Force/Position graph is shown below. Determine how much work is done by the Sun on the probe as the probe–Sun separation changes from 1.5×10^{11} m to 2.3×10^{11} m. (-3×10^{10} J)

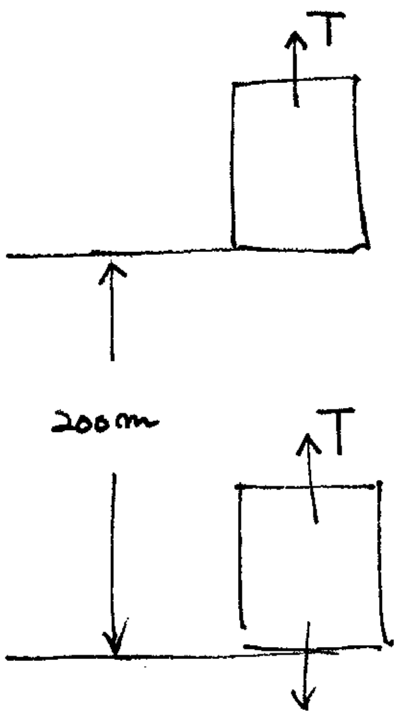


7. When a spring is stretched near its elastic limit, the spring force satisfies the equation, $F = -k x + \beta x^3$. If $k = 10$N/m and $\beta = 100$ N/m^3, calculate the work done by this force when the spring is stretched 0.1 m from its equilibrium position. (-0.048 J)

8. To stretch a certain nonlinear spring by an amount x requires a force F given by $F = 40x - 6x^2$, where F is in Newtons and x is in meters. What is the change in potential energy ΔU when the spring is stretched 2 meters from its equilibrium position? (64 J)

Power U4H5

1.



$t = 20$ sec.

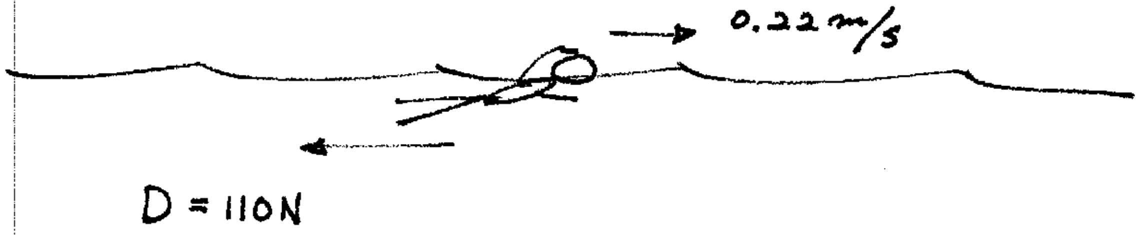
$$\text{Weight} = 3.0 \times 10^3 \times 10 = 3.0 \times 10^4 \text{ N}$$

$$\text{Power} = \frac{\text{Work}}{\text{time}} = \frac{3.0 \times 10^4 \times \not{2}0\not{0}^{10}}{\not{2}0}$$

$$= 3.0 \times 10^5 \text{ Watt}$$

Power U4H5.

2.



$$\text{Power} = \frac{\text{Work}}{\text{time}}$$

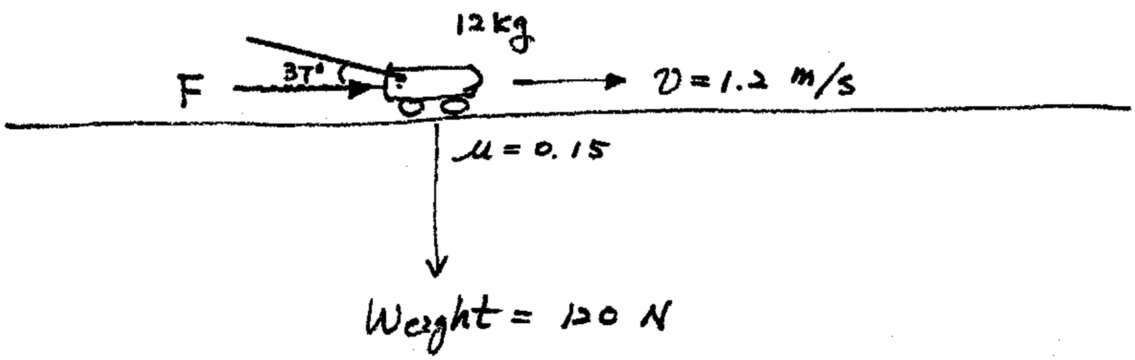
$= \text{Force} \times \text{speed}$

$= 110 \times 0.22$

$= 24.2$ Watt

Power U4H5

3.

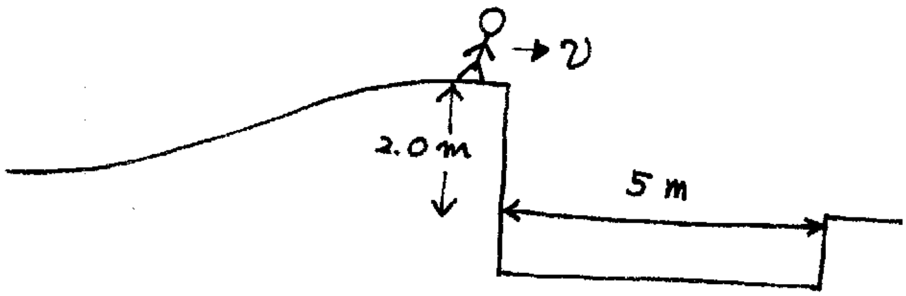


friction = $\mu \cdot N = 0.15 \times 120 = 18N = F$

Power = $F \cdot v = 18 \times 1.2 = 21.6$ Watt

Power W4 H5.

4.



x - direction

$v_x = v$

$x = vt$

$\therefore\ 5 \leqq v \cdot 0.63$

$v \geqq \frac{5}{0.63} = 7.9\ m/s.$

y - direction

$v_y = -10t$

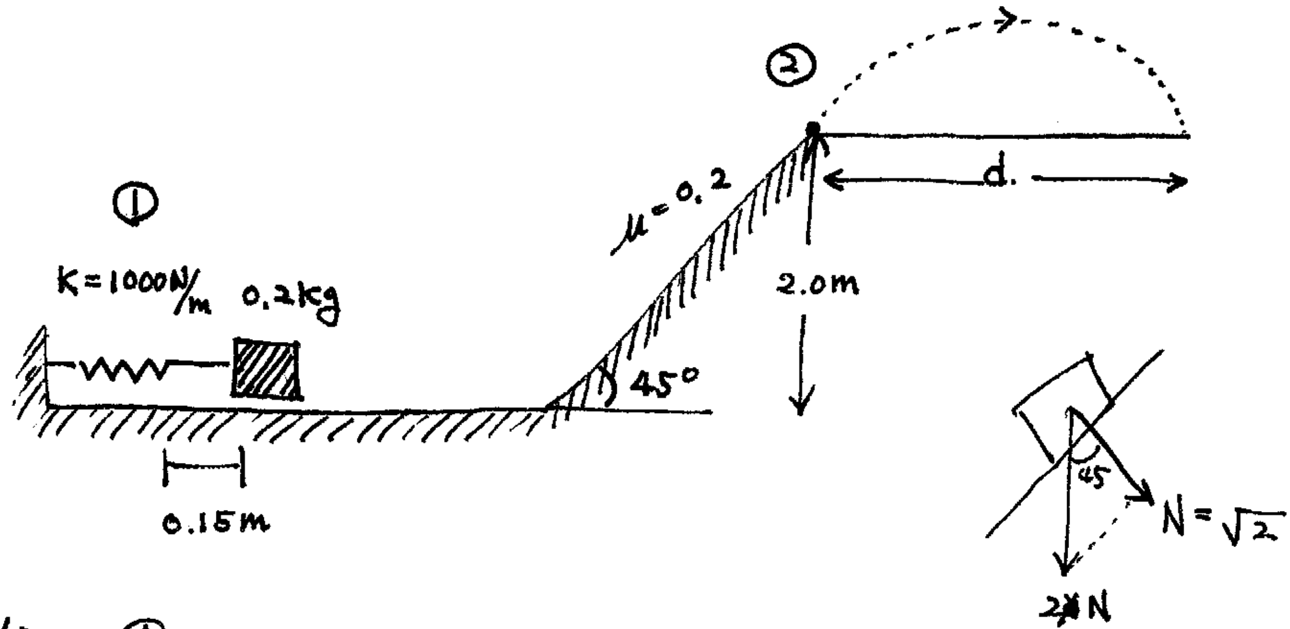
$y = -\frac{1}{2} \times 10t^2 = -5t^2$

$-2 = -5t^2$

$t = \sqrt{\frac{2}{5}} = 0.63$ sec

Power U4H5

5.



location ①

$P.E. = 0.$

$P.E._{spring} = \frac{1}{2}kx^2 = \frac{1}{2} \cdot 1000 \cdot 0.15^2 = 11.25\ J$

$K.E. = 0.$

$\therefore$ Total Energy $= 11.25\ J$

location ②.

$P.E. = mgh = 0.2 \times 10 \times 2 = 4$

$P.E._{spring} = 0.$

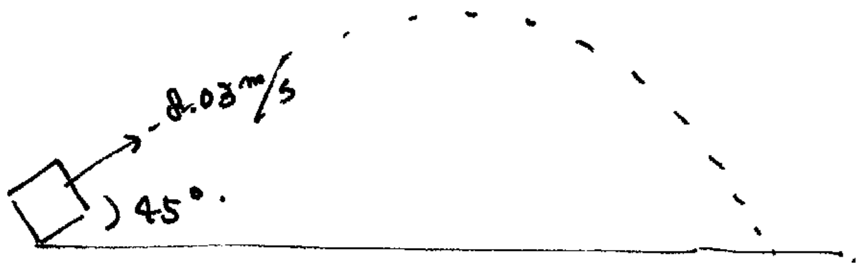
$K.E. = \frac{1}{2}mv^2 = \frac{1}{2} \cdot 0.2 \cdot v^2 = 0.1\, v^2$

Total Energy $= 4 + 0.1\, v^2 + 0.8$

Work by friction $= 0.2\sqrt{2} \cdot 2\sqrt{2} = 0.8.$

$11.25 = 4.8 + 0.1 v^2.$

$v = 8.03 \ m/s.$



x- direction.

$x = 8.03 \times \cos 45° \cdot t$

$= 5.68 t$

y - direction

$y = 8.03 \times \sin 45° t - \frac{1}{2} \cdot 10 \cdot t^2$

$= 5.68 t - 5t^2$

$0 = t(5.68 - 5t)$

$\therefore t = \frac{5.68}{5} = 1.136$

$\therefore D = 5.68 \times 1.136$

$= 6.45 \ m$

6.

$$\text{Work} = F \cdot s.$$

$$= \int_{1.5\times10^{11}}^{2.3\times10^{11}} F \cdot dx$$

$$= \int_{1.5\times10^{11}}^{2.3\times10^{11}} \frac{-1.3\times10^{22}}{x^2}\, dx.$$

$$= -3\times10^{10}\ \text{J}$$

7.

$$F = -kx + \beta x^3$$

$$= -10x + 100x^3$$

$$W = \int_0^{0.1} (-10x + 100x^3)\, dx$$

$$= -0.0475 \text{ J}$$

U4H5.

8. $F = 40x - 6x^2.$

$$\text{Work} = \int_0^2 (40x - 6x^2)\,dx$$

$$= 64\text{ J}.$$