Energy

1. A force 20-N **F** acts on a 3-kg object as it moves a distance of 4m. If **F** is perpendicular to the 4m displacement, the work is done equal to
A. 0 J B. 60 J C. 80 J D. 600 J E. 2400 J

2. How much work is done on a 4-kg object as it accelerates from 3 m/s to 6 m/s in 8s?
A. 27 J B. 54 J C. 72 J D. 96 J E. Can't be determined

3. What is the change in the gravitational potential energy of a box of mass m sliding down a frictionless inclined plane of length L and vertical height h?
A. $-mgL$ B. $-mgh$ C. $-mgL/h$ D. $-mgh/L$ E. $-mghL$

4. How much work is done by the centripetal force during one-half of a revolution on an object of mass m as it travels at constant speed v in a circular radius r?
A. πmv^2 B. $2\pi mv^2$ C. 0 D. $\pi mv^2 r$ E. $2\pi mv^2 r$

5. How much work does the gravitational potential force do on a book of mass 2kg while the person lifts the book from the floor to a tabletop 1.5 m above the floor?
A. –30 J B. –15 J C. 0 J D. 15 J E. 30 J

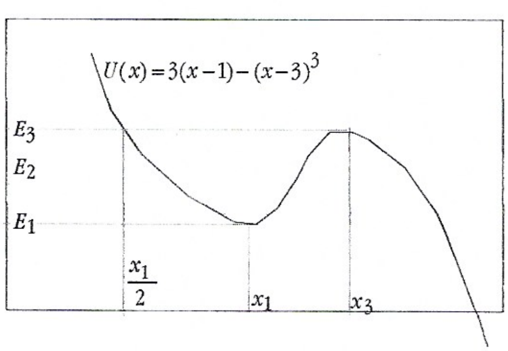
6. A 3.5-kg block is released from rest at the top of an frictionless 6-m plane inclined at a 30° angle with the horizontal. What is its speed at the bottom of the inclined plane?
A. 4.9 m/s B. 5.2 m/s C. 6.4 m/s D. 7.7 m/s E. 9.1 m/s

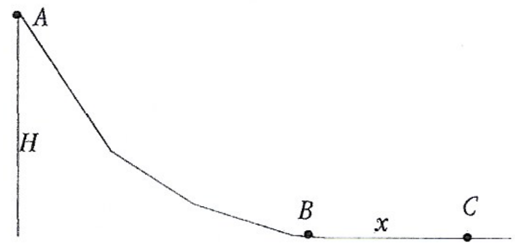
7. A 3.5-kg block is released from rest at the top of an frictionless 6-m plane inclined at a 60° angle with the horizontal. The coefficient of kinetic friction is μ=0.3. What is its speed at the bottom of the inclined plane?
A. 4.9 m/s B. 5.2 m/s C. 6.4 m/s D. 7.7 m/s E. 9.1 m/s

8. A 4-kg block is released from rest at the edge of a 40-m high cliff. It experiences 20-N air resistance. At what speed will the rock hit the ground?
A. 8 m/s B. 10 m/s C. 12 m/s D. 16 m/s E. 20 m/s

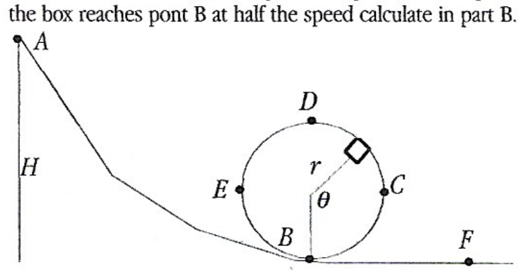
9. Anastronaut drops a rock from the top of a crater on the Moon. What fraction of its final impact speed is its speed at the halway point?
A. $\sqrt{2}/4$ B. 1/4 C. $\sqrt{2}/2$ D. 1/2 E. $1/\sqrt{2}$

10. A 200-N force is required to keep an object sliding at a constatn speed of 2 m/s across a rought floor. How much power is necessary to maint this motion?
A 50 W B. 100 W C. 200 W D. 400 W E. Can't be determined.





1. A box of mass m is released from rest at point A, at a height H above the level ground. The portion on the ground between the points B and C is rough with the kinetic coefficient of friction μ and its length is x. Answer all questions in terms of the givens.
A. Wht is the speed of the box when its at a height $H/2$?
B. What is the speed of the box at point B?
C. For what value μ does the box come to rest at point C?
D. Now assume point C is aboe B at a uniform ascending incline where the rise is y and the run is x. For what value μ does the box come to rest at point C?
E. If the slide is not frictionless, determine the work done by the friction as the box moves from point A to point B if the speed of the box reaches pont B at half the speed calculate in part B.



2. All the portions of the track shown above are frictionless except the portion between the points B and F. The mass m is released from rest at point A and enters the loop at point B.
   A. Obtain the centripetal acceleration of the car at point C.
   B. Determine the speed of the car at the position above in terms of the givens and θ.
   C. What is the ***min.*** speed the mass can have at point B in order to complete the loop without coming off the track?
   D. What is the minimum height H for the mass to complete the loop as described in part-C?
   E. If H=6r and the coefficient of friction between B and F is μ, how far along the flat portion will the mass travel before it comes to rest?

3. The PE of a 3-kg mass is given by $U(x) = 3(x-1) - (x-3)^3$. U is in J and x is in m. In the graph, $E_3 - E_2 = E_2 - E_1$ where $E_3 = U(x_3)$, $E_2 = U(x_2)$, $E_1 = U(x_1)$.
   A. Determine the numerical values of x_1 and x_3.
   B. Describe the motion of the particle if its total energy is E_2
   C. What is the particles's speed at $x = x_1$ it its total energy E=58J?
   D. Sketch the graph of the particle's acceleration as a function of ^x. Be sure to indicate x_1 and x_3 on it.
   E. The particle is released from rest at $x = \frac{x_1}{2}$. What is its speed at $x = x_1$?

4. The force on a 6kg object is given by $F = 3x + 5$ in N. The object is moving 2 m/s at the origin. When it is moved 4 m from origin
   A. Determine the work odone on the object.
   B. Determine its speed.

PR 4 Energy

Black 13 Black + Blue 19
Blue 6
Red 3
Total 22

1) A ✓

2) $W = \frac{1}{2}m(v_f^2 - v_0^2)$

$= \frac{1}{2}(4\,kg)(6\,\frac{m}{s}^2 - 3\,\frac{m}{s}^2)$

$= 54\,J$ (B) ✓

3) $PE_g = mgh$ (B) ✓

4) $W = 0$; $\perp$ (C) ✓

5) $W = -\Delta PE = -mgh = -(2\,kg)(10)(1.5)$

$= -30\,J$ (A) ✓

6) 

$\frac{1}{2}\cancel{m}v_f^2 = \cancel{m}g\,l\sin\theta$

$v_f = \sqrt{2gl\sin\theta}$

$= \sqrt{2(10\,\frac{m}{s^2})(6\,m)(\frac{1}{2})}$ ✓

$= \sqrt{60}\,\frac{m}{s} = 7.7\,\frac{m}{s}$ (B)

7) $\cancel{m}gh = \frac{1}{2}\cancel{m}v_f^2 - \mu\cancel{m}g\cos\theta\,l$

$v_f^2 = \sqrt{2gh + 2\mu g\cos\theta\,l}$

$= \sqrt{2(10)(6\sin 60) + 2(0.3)(10)(6\,m)\cos 60}$

$= 13.4\,m/s$ (C)? × E

8) $\frac{1}{2}mv_f^2 = mgh - (20N)\,40m$

$v_f^2 = 2gh - \frac{20N \cdot 40m \cdot 2}{m}$

$v_f = 20\,\frac{m}{s}$ (E) ✓

9) $\cancel{m}gh_0 = \frac{1}{2}\cancel{m}v_m^2 + \cancel{m}g\frac{1}{2}h_0 = \frac{1}{2}\cancel{m}v_f^2$

$2gh_0 = v_m^2 + gh_0 = v_f^2$

$v_m^2 = 2gh_0 - gh_0$ ✓ $v_f^2 = 2gh_0$

(E)/(C) $v_m^2 = gh_0$ $v_m^2 = \frac{1}{2}v_f^2$ $v_m = \frac{\sqrt{2}}{2}v_f$

10) $P = \frac{W}{t} = F \cdot v\cos\theta = Fv = 400\,W$ (D) ✓

FRQ

1) A) $mgH = \frac{1}{2}v_m^2 + \frac{1}{2}mgH$

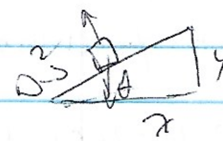
$v^2 = \cancel{m}gH$

$v = \sqrt{gH}$ ✓

B) $v_f = \sqrt{2gH}$ ✓

c) $\cancel{m}gH = \mu\cancel{m}g\,x$

$\mu = \frac{H}{x}$ ~

d) $\cancel{m}gH = \cancel{m}gy + \mu\cancel{m}gx\cos\theta$ 

Plugging $H = y + \mu x\cos\theta$

$= y + \mu x \frac{x}{\sqrt{x^2+y^2}}$

$= y + \mu\frac{x^2}{\sqrt{x^2+y^2}}$

$\boxed{\mu = \frac{H - y\sqrt{x^2+y^2}}{x^2}}$ ~

e) $mgH = \frac{1}{2}mv_f^2 + W_f$

$mgH = \frac{1}{2}m\left(\frac{1}{2}\sqrt{2gH}\right)^2 + W_f$

$mgH = \frac{1}{8}m \cdot 2gH + W_f$

$W_f = mgH\left(1 - \frac{1}{4}\right)$

$\boxed{W_f = \frac{3}{4}mgH}$

dissipates energy 3

2) A) $mgH = mgr + \frac{1}{2}mv_c^2$

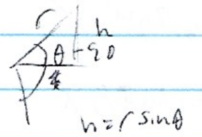
$v_c^2 = 2gH - 2gr$

$a_c = \frac{v_c^2}{r} = \frac{2gH}{r} - 2g$

$= 2g\left(\frac{H}{r} - 1\right)$ ✓

B) $mgH = mgl + \frac{1}{2}mv^2$

$l = r + r\sin(\theta - 90)$



$= r(1 - \cos\theta)$

$mgH = mgr(1-\cos\theta) + \frac{1}{2}mv^2$

$2gH - 2gr(1-\cos\theta) = v^2$

$v = \sqrt{2g(H - r(1-\cos\theta))}$ ✓

C) $\frac{1}{2}mv_b^2 = mg2r$

$v_b^2 = 4gr$

$v = 2\sqrt{gr}$ ~

d) $mgH = mg2r$

$H = 2r$ ~

e) $mg6r = \mu mgl$

$l = \frac{6r}{\mu}$ $\frac{.6r}{\mu} = 12r$?

2

3) $y(x_3) - y(x_2) = y(x_2) - y(x_1)$

$x_3 - x_2 = x_2 - x_1$

$2x_2 = x_3 + x_1$?? ~~~

4) $W = F \cdot d = (3x + 5)x$

$= 3x^2 + 5x$

$= 3(4^2) + 5(4) = 16 \cdot 3 + 20$

$= 68\ J$

$\frac{1}{2}mv_f^2 = 68\ J$

$\Delta v = \sqrt{\frac{2 \cdot 68}{m}}$

$= \sqrt{\frac{136}{6}}$

$= 4.7\ \frac{m}{s}$

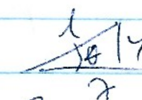
$v_f = 4.7\ \frac{m}{s}$

16 × 3 = 48

68 × 2 = 136

1) d) $mgH = mgy + \mu N l$

$= mgy + \mu mg\cos\theta\, l$



$x = l\cos\theta$

$H = y + \mu x$

$\mu = \frac{H - y}{x}$ ✓

1) c) is the solution using the same thing as the problem?

2) c) $F_c = \frac{mv^2}{r} = mg$

$v = \sqrt{5g}$ ✓

2) d) $PE_0 + KE_0 = PE_f + KE_f$

$mgh_0 = mg2r + \frac{1}{2}mv_c^2$

2

$mgh_0 = mg2r + \frac{1}{2}mv_c^2$

$\cancel{m}gh_0 = \cancel{m}g2r + \frac{1}{2}\cancel{m}gr$

$\boxed{h_0 = \frac{5}{2}r}$ ✓

3) at x_1 & x_3, $\frac{dU}{dx} = 0$

a) $\frac{dU}{dx} = -3(x-3)^2 + 3 = 0$

$(x-3)^2 = 1$

$x - 3 = \pm 1$

$x = 2, 4$

$x_1 = 2$ $\quad x_3 = 4$ ✓

b) E_2 is between E_1 and E_3, which means it's inbetween x_1 and x_3

if U is a function of x, U is directly proportional to its height, but energy is conserved. we assume it comes in the form of kinetic energy. ~

It is higher than at x_1, but faster than at x_3.

c) $U(x_1) = 3(1) - (-1)^3$

$= 3 + 1 = 4$ J PE

$KE = 54$ J $= \frac{1}{2}mv^2$

$v_x = \sqrt{\frac{2(54J)}{3kg}} = 6$ m/s ✓

3

d) $U = mgh$ $\quad KE = \frac{1}{2}mv_f^2$

$E_{total} = mgh + \frac{1}{2}mv^2$ ~

e) $x = 1$ $\quad E = E_3 = 58$ J

$U_3 = 3(3) - (1)^3 = 8$ J

$mgh_0 + \cancel{\frac{1}{2}mv_0^2} = mgh_f + \frac{1}{2}mv_f^2$

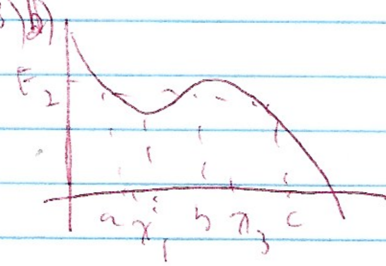
8 J $+$ ...

$= 4$ J $+ \frac{1}{2}mv_f^2$ ✓

$v_f = \sqrt{\frac{8J}{m}} = \sqrt{\frac{8}{3}} = \boxed{1.63 \text{ m/s}}$

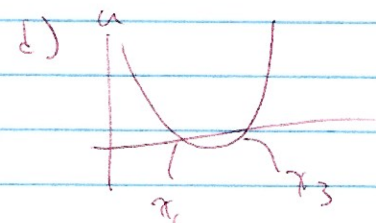
1

3)b)



the obj. oscillates b/w a & b ✓

d)



✓

HC 7) $\cancel{KE_0} + PE_0 + W_f = KE_f + \cancel{PE_f}$

$mgh - F_f l = \frac{1}{2}mv_f^2$

$mgl\sin\theta - \mu mg\cos\theta\, l = \frac{1}{2}mv_f^2$

$v_f = 9.2$ m/s (c) ✓

3

CHAPTER 4 MC

1. A $\vec{F} \perp \vec{d} \Rightarrow W = \vec{F}\cdot\vec{d} = 0$

2. B $W = KE_2 - KE_1$

$= \frac{1}{2} 4kg \left((6\frac{m}{s})^2 - (3\frac{m}{s})^2\right) = 54J$

3. B mgh h = the change in height

$h = d\cos\theta$

4. C In a circular motion:

$\vec{F}_c$: towards the center

$\vec{d}$: tangent (displacement)

$\Rightarrow W = \vec{F}_c \cdot \vec{d} = 0$

5. A $m\vec{g}\cdot\vec{d} = mg\downarrow \cdot d\uparrow = -30J$

$= mgd\cos 180° = -mgd$

6. D $W = mg\sin\theta\, L = 103J$

$W = \frac{1}{2}m(v^2 - v_0^2) = \frac{1}{2}mv^2$

$v = 7.7\, m/s$

7. E $KE_1 + PE_1 + W_f = KE_2 + PE_2$

$0 + mgh - F_f L = \frac{1}{2}mv^2 + 0$

$mg\, L\sin\theta - \mu mg\cos\theta\, L = \frac{1}{2}mv^2$

$v = 9.2\, \frac{m}{s}$

8. E $KE_1 + PE_1 + W_r = KE_2 + PE_2$

$0 + mgh - F_r h = \frac{1}{2}mv^2 + 0$

$v = 20\, \frac{m}{s}$

9. E $PE_{midpt} = \frac{1}{2} PE_{max} = \frac{1}{2} KE_{max}$

$KE = \frac{1}{2} KE_{max}$

$v = \frac{1}{\sqrt{2}} v_{max}$, $(KE = \frac{1}{2}mv^2)$

10. D $P = Fv = 400W$

OE

1. a C.o.E: $KE_A + PE_A = KE_{\frac{h}{2}} + PE_{\frac{h}{2}}$

$0 + mgH = \frac{1}{2}mv^2 + mg\frac{H}{2}$

$v = \sqrt{gH}$

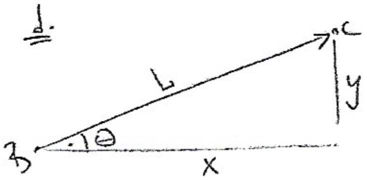
b C.o.E $\Rightarrow 0 + mgH = \frac{1}{2}mv_B^2 + 0$

$v_B = \sqrt{2gH}$

c. $W = \Delta KE = \frac{1}{2}m(v_C^2 - v_B^2) = -\frac{1}{2}mv_B^2$

$-\frac{1}{2}m(\sqrt{2gH})^2 = -mgH = W$

d.



$KE_B + PE_B + W_f = KE_C + PE_C$

$\frac{1}{2}m(\sqrt{2gH})^2 + 0 - F_f L = 0 + mgy$

$mg(H-y) - \mu_k mg\cos\theta\, L = 0$

$\mu_k = \frac{H-y}{x}$, $x = L\cos\theta$

e. $v_B = \sqrt{2gH}$

$KE_A + PE_A + W_f = KE'_B + PE_B$

$0 + mgH + W_f = \frac{1}{2}m(\frac{1}{2}v_B)^2 + 0$

$mgH + W_f = \frac{1}{4}mgH$

$W_f = -\frac{3}{4}mgH$

2. a $a_c = \frac{v_c^2}{r}$

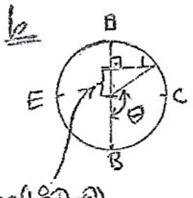
C.o.E: $KE_A + PE_A = KE_C + PE_C$

$0 + mgH = \frac{1}{2}mv_c^2 + mgr$

$mg(H-r) = \frac{1}{2}mv_c^2$

$a_c = \frac{v_c^2}{r} = \frac{2g(H-r)}{r}$

b



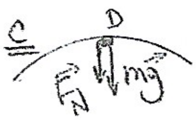
$r\cos(180-\theta) = -r\cos\theta$

$KE_A + PE_A = KE + PE$

$0 + mgH = \frac{1}{2}mv^2 + mg(r - r\cos\theta)$

$v = \sqrt{2g[H - r(1-\cos\theta)]}$

c



$mg + F_N = m\frac{v^2}{r}$

$F_N = 0$ for cut-off

$v_{c.o.} = \sqrt{gr}$

d C.o.E: $KE_A + PE_A = KE_D + PE_D$

$0 + mgH = \frac{1}{2}mv_{c.o.}^2 + mg(2r)$

$= \frac{1}{2}mgr + 2mgr$

$H = \frac{5}{2}r$

e C.o.E: $KE_A + PE_A = KE_B + PE_B$

$0 + mg(6r) = \frac{1}{2}mv_B^2 + 0$

$6mgr = \frac{1}{2}mv_B^2$

$W = \Delta KE = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_B^2 = -\frac{1}{2}mv_B^2$

$-F_f \cdot x = -6mgr$, $F_f = \mu mg$

$x = \frac{6r}{\mu} = 12r$

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3. a $x = x_1$ is a local minimum of $U(x)$

$x = x_3$ is a local maximum

$\Rightarrow \frac{dU}{dx} = 0$ (slope $= 0$)

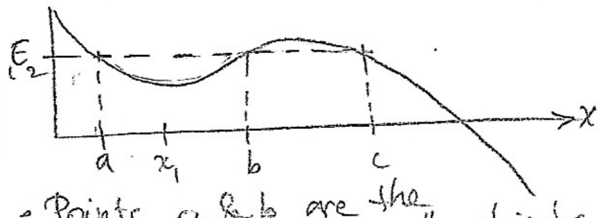
$\Rightarrow 3 - 3(x-3)^2 = 0 \Rightarrow (x-3) = \pm 1$

$x = 2, 4$, $x_1 = 2m$, $x_3 = 4m$

b $E_2 = \frac{1}{2}(E_1 + E_3) = \frac{1}{2}[U(\frac{x_1}{2}) + U(x_3)]$

$= \frac{1}{2}[U(2) + U(4)] = 6J$

The particle osillate between a & b.



- Points a & b are the turning points where the objects has 0 instantaneous velocity
- The particle cannot be between b & c since it does not have enough energy (However, this can happen quantum mechanically!)

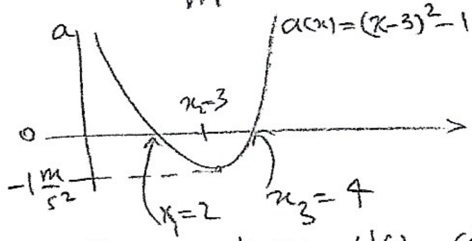
c $KE + U = E \Rightarrow KE = E - U$

$K(x_1) = E - [3(x-1) - (x-3)^3]_{x=2} = 58J - [3 - (-1)] = 54J$

$\frac{1}{2}mv_1^2 = 54J \Rightarrow v_1 = 6\frac{m}{s}$

d $F(x) = -\frac{dU}{dx} = 3(x-3)^2 - 3$

$a(x) = \frac{F(x)}{m} = (x-3)^2 - 1$ (in $\frac{m}{s^2}$)



e $x = \frac{x_1}{2}$, $E_3 = U(\frac{x_1}{2}) = U(1) = 8J$

$U(x_1) = U(2) = 4J$, $[U(x) = 3(x-1) - (x-3)^3]$

$K = E - U = 8J - 4J = 4J$

$\Rightarrow v = 1.6\frac{m}{s}$