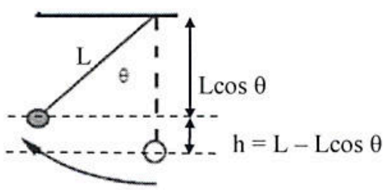
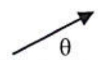
ANSWERS - AP Physics Multiple Choice Practice – Work-Energy

	Solution	Answer
1.	Conservation of Energy, $U_{sp} = K$, $\frac{1}{2} kA^2 = \frac{1}{2} mv^2$ solve for v	B
2.	Constant velocity → $F_{net}=0$, $f_k = Fx = F\cos\theta$ $W_{fk} = -f_k d = -F\cos\theta\, d$	A
3.	Try out the choices with the proper units for each quantity. Choice A … FVT = (N) (m/s) (s) = Nm which is work in joules same as energy.	A
4.	Two step problem. Do $F = k\Delta x$, solve for Δx then sub in the $U_{sp} = \frac{1}{2} k\Delta x^2$	A
5.	In a circle moving at a constant speed, the work done is zero since the Force is always perpendicular to the distance moved as you move incrementally around the circle	E
6.	 The potential energy at the first position will be the amount "lost" as the ball falls and this will be the change in potential. $U=mgh = mg(L-L\cos\theta)$	A
7.	A force directed above the horizontal looks like this  To find the work done by this force we use the parallel component of the force (Fx) x distance. = $(F\cos\theta)\, d$	B
8.	The maximum speed would occur if all of the potential energy was converted to kinetic $U = K$ $16 = \frac{1}{2} mv^2$ $16 = \frac{1}{2} (2) v^2$	B
9.	The work done by the stopping force equals the loss of kinetic energy. $-W=\Delta K$ $-Fd = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2$ $v_f = 0$ $F = mv^2/2d$	A
10.	The work done by friction equals the loss of kinetic energy $-f_k\, d = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2$ $v_f = 0$, plug in values to get answer	D
11.	P = Fd / t. Since there is no distance moved, the power is zero	E
12.	This is a conservative situation so the total energy should stay same the whole time. It should also start with max potential and min kinetic, which only occurs in choice C	C
13.	Stopping distance is a work-energy relationship. Work done by friction to stop = loss of kinetic $-f_k\, d = -\frac{1}{2} mv_i^2$ $\mu_k mg = \frac{1}{2} mv_i^2$ The mass cancels in the relationship above so changing mass doesn't change the distance	B
14.	Same relationship as above … double the v gives 4x the distance	E
15.	Half way up you have gained half of the height so you gained ½ of potential energy. Therefore you must have lost ½ of the initial kinetic energy so $E_2 = (E_k/2)$. Subbing into this relationship $E_2 = (E_k/2)$ $\frac{1}{2} mv_2^2 = \frac{1}{2} m v^2 / 2$ $v_2^2 = v^2 / 2$ …. Sqrt both sides gives answer	B
16.	At the top, the ball is still moving (v_x) so would still possess some kinetic energy	A
17.	Same as question #1 with different variables used	E

18. $P = F d / t$ $= (ma)d / t$ $= (kg)(m/s^2)(m) / (s)$ $= kg\ m^2 / s^3$ C

19. $P = Fv$, plug in to get the pushing force F and since its constant speed, $F_{push} = f_k$ A

20. Total energy is always conserved so as the air molecules slow and lose their kinetic energy, there is a heat flow which increases internal (or thermal) energy C

21. The work done must equal the increase in the potential energy $mgh = (10)(10)(1.3)$ D

22. Based on $F = k\ \Delta x$. The mass attached to the spring does not change the spring constant so the same resistive spring force will exist, so the same stretching force would be required C

23. The work done must equal the total gain in potential energy B
10 boxes * mgh (25)(10)(1.5) of each

24. Eliminating obviously wrong choices only leaves A as an option. The answer is A because since the first ball has a head start on the second ball it is moving at a faster rate of speed at all times. When both are moving in the air together for equal time periods the first faster rock will gain more distance than the slower one which will widen the gap between them. A

25. All of the $K = ½\ m\ v^2$ is converted to U. Simply plug in the values D

26. For a mass on a spring, the max U occurs when the mass stops and has no K while the max K occurs when the mass is moving fast and has no U. Since energy is conserved it is transferred from one to the other so both maximums are equal D

27. Since the ball is thrown with initial velocity it must start with some initial K. As the mass falls it gains velocity directly proportional to the time (V=Vi+at) but the K at any time is equal to $1/2\ mv^2$ which gives a parabolic relationship to how the K changes over time. E

28. Since the speed is constant, the pushing force F must equal the friction force $f_k = \mu F_n = \mu mg$. The power is then given by the formula $P = Fv = \mu mgv$ C

29. Since the speed is constant, the pushing force F must equal the friction force (10 N). The distance traveled is found by using d = vt = (3)(60 sec), and then the work is simply found using W=Fd E

30. Only conservative forces are acting which means mechanical energy must be conserved so it stays constant as the mass oscillates E

31. The box momentarily stops at x(min) and x(max) so must have zero K at these points. The box accelerates the most at the ends of the oscillation since the force is the greatest there. This changing acceleration means that the box gains speed quickly at first but not as quickly as it approaches equilibrium. This means that the K gain starts of rapidly from the endpoints and gets less rapid as you approach equilibrium where there would be a maximum speed and maximum K, but zero force so less gain in speed. This results in the curved graph. D

32. Point IV is the endpoint where the ball would stop and have all U and no K. Point II is the minimum height where the ball has all K and no U. Since point III is halfway to the max U point half the energy would be U and half would be K C

33. Apply energy conservation using points IV and II. $U_4 = K_2$ $mgh = ½\ mv^2$ B

34. Force is provided by the weight of the mass (mg). Simply plug into $F=k\Delta x$, $mg=k\Delta x$ and solve E

35. Since the track is rough there is friction and some mechanical energy will be lost as the block slides which means it cannot reach the same height on the other side. The extent of energy lost depends on the surface factors and cannot be determined without more information — E

36. The force needed to lift something at a constant speed is equal to the object weight F=mg. The power is then found by P = Fd / t = mgh / t — E

37. Simple energy conservation $K=U_{sp}$ $\frac{1}{2} m v_o^2 = \frac{1}{2} k \Delta x^2$ solve for Δx — D

38. Simple application of $F_g=mg$ — D

39. $F_n = F_{gy} = mg \cos \theta$. Since you are given the incline with sides listed, $\cos \theta$ can be found by using the dimensions of the incline … $\cos \theta$ = adj / hyp = 4/5 to make math simple. This is a good trick to learn for physics problems — C

40. As the box slides down the incline, the gravity force is parallel to the height of the incline the whole time so when finding the work or gravity you use the gravity force for F and the height of the incline as the parallel distance. Work = $(F_g)(d) = (20)(3)$ — B

41. The student must exert an average force equal to their weight (F_g) in order to lift themselves so the lifting force F=mg. The power is then found with $P = Fd / t = (F_g)d / t$ — C

42. As the object oscillates its total mechanical energy is conserved and transfers from U to K back and forth. The only graph that makes sense to have an equal switch throughout is D — D

43. To push the box at a constant speed, the child would need to use a force equal to friction so $F=f_k=\mu mg$. The rate of work (W/t) is the power. Power is given by $P=Fv \rightarrow \mu mgv$ — A

44. Two steps. I) use hookes law in the first situation with the 3 kg mass to find the spring constant (k). $F_{sp}=k\Delta x$, $mg=k\Delta x$, $k = 30/.12 = 250$. II) Now do energy conservation with the second scenario (note that the initial height of drop will be the same as the stretch Δx).
U top = U_{sp} bottom, $mgh = \frac{1}{2} k \Delta x^2$, $(4)(10)(\Delta x) = \frac{1}{2} (250) (\Delta x^2)$ — D

45. In a circular orbit, the velocity of a satellite is given by $v = \sqrt{\frac{Gm_e}{r}}$ with $m_e = M$. Kinetic energy of the satellite is given by $K = \frac{1}{2} m v^2$. Plug in v from above to get answer — B

46. Projectile. V_x doesn't matter $V_{iy} = 0$. Using $d = v_{iy}t + \frac{1}{2} at^2$ we get the answer — E

47. Energy conservation $E_{top} = E_{bot}$, $K_t+U_t = K_b$. Plug in for K top and U top to get answer — D

48. A is true; both will be moving the fastest when they move through equilibrium. — A

49. X and Y directions are independent and both start with the same velocity of zero in each direction. The same force is applied in each direction for the same amount of time so each should gain the same velocity in each respective direction. — C

50. Kinetic energy is not a vector and the total resultant velocity should be used to determine the KE. For the 1st second the object gains speed at a uniform rate in the x direction and since KE is proportional to v^2 we should get a parabola. However, when the 2nd second starts the new gains in velocity occur only in the y direction and are at smaller values so the gains essentially start over their parabolic trend as shown in graph B — B

51. Simple P = Fv — E

52. The force needed to lift something at a constant speed is equal to the object weight F=mg. The power is then found by P = Fd / t = mgh / t — B

53. As the system moves, m_2 loses energy over distance h and m_1 gains energy over the same distance h but some of this energy is converted to KE so there is a net loss of U. Simply subtract the $U_2 - U_1$ to find this loss — A

54. In a force vs. displacement graph, the area under the line gives the work done by the force and the work done will be the change in the K so the largest area is the most K change — E

55. Compare the U+K (mgh + ½ mv^2) at the top, to the K (½ mv^2) at the bottom and subtract them to get the loss. — C

56. Use energy conservation, U top = K bottom. As in problem #6 (in this document), the initial height is given by L – Lcos θ, with cos 60 = .5 so the initial height is ½ L. — A

57. Use application of the net work energy theorem which says … $W_{net} = \Delta K$. The net work is the work done by the net force which gives you the answer — A

58. First use the given location (h=10m) and the U there (50J) to find the mass. U=mgh, 50=m(10)(10), so m = 0.5 kg. The total mechanical energy is given in the problem as U+K = 100 J. The max height is achieved when all of this energy is potential. So set 100J = mgh and solve for h — B

59. There is no U_{sp} at position x=0 since there is no Δx here so this is the minimum U location — A

60. Simple P = Fv to solve — E

61. Using energy conservation in the first situation presented K=U gives the initial velocity as $v = \sqrt{2gh}$. The gun will fire at this velocity regardless of the angle. In the second scenario, the ball starts with the same initial energy but at the top will have both KE and PE so will be at a lower height. The velocity at the top will be equal to the v_x at the beginning — C

$$v_x = v\cos\theta = \left(\sqrt{2gh}\right)\cos 45 = \left(\sqrt{2gh}\right)\left(\frac{\sqrt{2}}{2}\right) = \sqrt{gh}$$

. Now sub into the full energy conservation problem for situation 2 and solve for h_2. $K_{bottom} = U_{top} + K_{top}$

$$\frac{1}{2}m\left(\sqrt{2gh}\right)^2 = mgh_2 + \frac{1}{2}m\left(\sqrt{gh}\right)^2$$

62. To find work we use the parallel component of the force to the distance, this gives Fcos θ d — B

63 The centripetal force is the force allowing the circular motion which in this case is the spring force F_{sp}=kΔx=(100)(.03) — B

64. In a circle at constant speed, the work done is zero since the Force is always perpendicular to the distance moved as you move incrementally around the circle — A

65. At the maximum displacement the K=0 so the 10J of potential energy at this spot is equal to the total amount of mechanical energy for the problem. Since energy is conserved in this situation, the situation listed must have U+K add up to 10J. — B

66. Using the work-energy theorem. $W_{nc} = \Delta$ ME, A
$W_{Ft} = \Delta U + \Delta K$,
$-Fd = (mgh_f - mgh_i) + (\frac{1}{2}mv_f^{\,2} - \frac{1}{2}mv_i^{\,2})$,
$-(11000)(8) = (0 - (1000)(10)(8)) + (0 - \frac{1}{2}(1000)(v_i^2)$ ... solve for v_i

67. Use energy conservation $K=U_{sp}$ $\frac{1}{2} mv_m^{\,2} = \frac{1}{2} k \Delta x^2$, with $\Delta x=A$, solve for k D

68. To lift the mass at a constant velocity a lifting force equal to the objects weight would be needed, so F=(mg). Simply plug into P = Fd / t and solve for d. C

69. Using the vertical distance with the vertical force ($Fd_{\|}$) B
W = 10 cartons * $(mg)(d_y)$ = 10 * (25)(10m/s^2)(1.5m) = 3750J

70. The ΔU will equal the amount of initial K based on energy conservation, $U = K = 1/2\ m\ v^2$ D

71. Using work-energy. $W_{nc} = \Delta K = K_f - K_i$ $\quad -Fd = 0 - \frac{1}{2} m\ v_f^{\,2}$ $\quad -F(95) = -\frac{1}{2}(500)28^2$ C

72. Based on net work version of work energy theorem. $W_{net} = \Delta K$, we see that since there is a constant speed, the ΔK would be zero, so the net work would be zero requiring the net force to also be zero. A

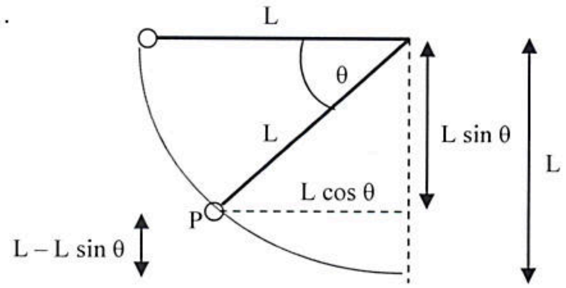
73. As the block slides back to equilibrium, we want all of the initial spring energy to be dissipated by work of friction so there in no kinetic energy at equilibrium where all of the spring energy is now gone. So set work of friction = initial spring energy and solve for μ. The distance traveled while it comes to rest is the same as the initial spring stretch, d = x. C
$\frac{1}{2} kx^2 = \mu mg(x)$

74. V at any given time is given by $v = v_i + at$, with $v_i = 0$ gives $v = at$, D
V at any given distance is found by $v^2 = v_i^{\,2} + 2\ ad$, with $v_i = 0$ gives $v^2 = 2ad$
This question asks for the relationship to distance.
The kinetic energy is given by $K = \frac{1}{2} m\ v^2$ and since $v^2 = 2ad$ we see a linear direct relationship of kinetic energy to distance (2*d → 2*K)
Another way of thinking about this is in relation to energy conservation. The total of $mgh+1/2mv^2$ must remain constant so for a given change in (h) the $\frac{1}{2} mv^2$ term would have to increase or decrease directly proportionally in order to maintain energy conservation.

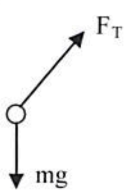
75. Similar to the discussion above. Energy is conserved so the term $mgh + \frac{1}{2} mv^2$ must remain constant. As the object rises it loses K and gains U. Since the height is H/2 it has gained half of the total potential energy it will end up with which means it must have lost half of its kinetic energy, so its K is half of what it was when it was first shot. B

76. Since the force is always perpendicular to the incremental distances traveled as the particle travels the loop, there is zero work done over each increment and zero total work as well. A

1974B1.



(a) FBD



(b) Apply conservation of energy from top to point P

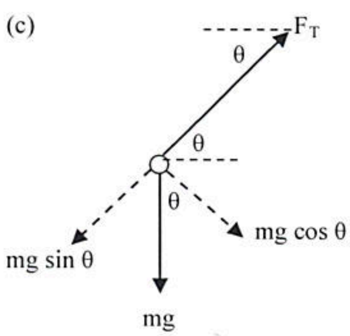
$U_{top} = U_p + K_p$

$mgh = mgh_p + ½ m v_p^2$

$gL = g(L - L\sin\theta) + ½ v_p^2$

$v = \sqrt{2gL\sin\theta}$

(c)



$F_{NET(C)} = m v^2 / r$

$F_T - mg\sin\theta = m v^2 / r$

$F_T - mg\sin\theta = m (2gL\sin\theta) / L$

$F_T = 2mg\sin\theta + mg\sin\theta$

$F_T = 3mg\sin\theta$

1974B7.

6 riders per minute is equivalent to 6x(70kg)*9.8 = 4116 N of lifting force in 60 seconds

Work to lift riders = work to overcome gravity over the vertical displacement (600 sin 30)
Work lift = Fd = 4116N (300m) = 1.23×10^6 J

P lift = W / t = 1.23×10^6 J / 60 sec = 20580 W

But this is only 40% of the necessary power. → 0.40 (total power) = 20580 W

Total power needed = 51450 W

1975B1.

(a) $F_{net} = ma$ $\quad - f_k = ma$ $\quad -8 = 2a$ $\quad a = -4 \text{ m/s}^2$

(b) $v_f^2 = v_i^2 + 2ad$ $\quad (0)^2 = v_i^2 + 2(-4)(8)$ $\quad v_i = 8 \text{ m/s}$

$v_f = v_i + at$ $\quad t = 2 \text{ sec}$

(c) Apply energy conservation top to bottom

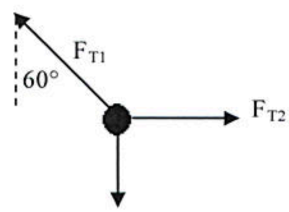
$U_{top} = K_{bot}$

$mgh = ½ mv^2$

$(10)(R) = ½ (8)^2$ $\quad R = 3.2 \text{ m}$

1975 B7

(a)

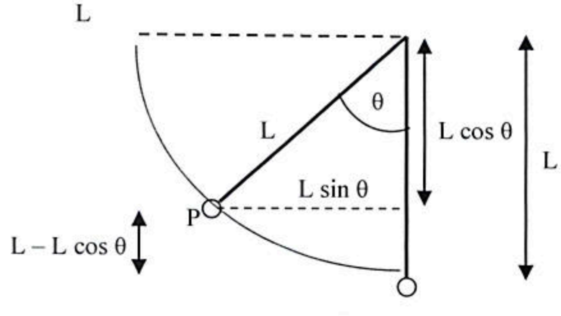


(b) $F_{NET(Y)} = 0$

$F_{T1} \cos\theta = mg$

$F_{T1} = mg / \cos(60) = 2mg$

(c) When string is cut it swing from top to bottom, similar to diagram for 1974B1 with θ moved as shown below



$U_{top} = K_{bot}$

$mgh = ½ mv^2$

$$v = \sqrt{2g(L - L\cos 60)}$$

$$v = \sqrt{2g(L - \frac{L}{2})}$$

$$v = \sqrt{gL}$$

Then apply $F_{NET(C)} = mv^2 / r$

$(F_{T1} - mg) = m(gL) / L$

$F_{T1} = 2mg$. Since it's the same force as before, it will be possible.

1977B1.

(a) Apply work–energy theorem

$W_{NC} = \Delta ME$

$W_{fk} = \Delta K \quad (K_f - K_i)$

$W = -K_i$

$W = -\frac{1}{2} mv_i2 \qquad -\frac{1}{2}(4)(6)^2 \qquad = -72\text{ J}$

(b) $F_{net} = ma$

$-f_k = m\,a \qquad v = v_i + at$

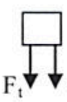
$a = -(8)/4 = -2\text{ m/s}^2 \qquad v = (6) + (-2)\,t$

(c) $W_{fk} = -f_k\,d$

$-72\text{J} = -(8)\,d \qquad d = 9\text{ m}$

1978B1,

(a)



(b) Apply $F_{net(C)} = mv^2 / r$ … towards center as + direction

$(F_t + mg) = mv^2/r \qquad (20+0.5(10))=(0.5)v^2 / 2 \qquad v = 10\text{ m/s}$

(c) As the object moves from P to Q, it loses U and gains K. The gain in K is equal to the loss in U.

$\Delta U = mg\Delta h = (0.5)(10)(4) = 20\text{ J}$

(d) First determine the speed at the bottom using energy.

$K_{top} + K_{gain} = K_{bottom} \qquad \frac{1}{2} mv_{top}^2 + 20\text{ J} = \frac{1}{2} mv_{bot}^2 \qquad v_{bot} = 13.42\text{ m/s}$

At the bottom, Ft acts up (towards center) and mg acts down (away from center)

Apply $F_{net(C)} = mv^2 / r$ … towards center as + direction

$(F_t - mg) = mv^2/r \qquad (F_t - 0.5(10)) = (0.5)(13.42)^2 / 2 \qquad F_t = 50\text{ N}$

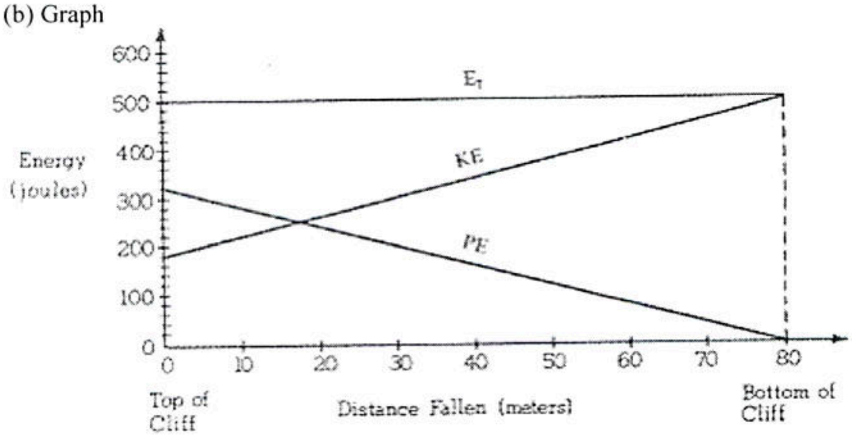
1979B1.

(a) $U = mgh = 320$ J

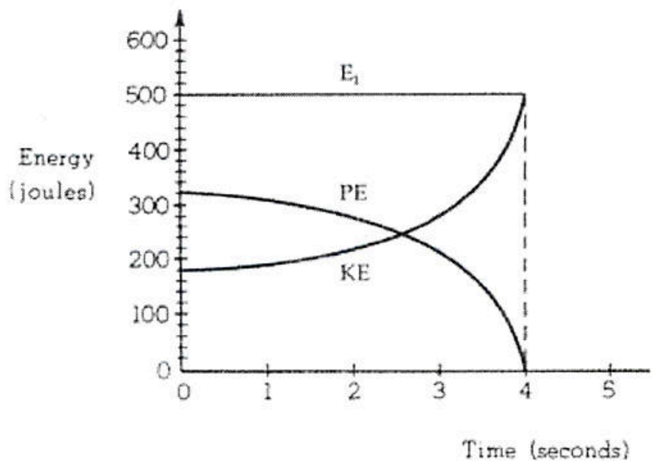
$K = \frac{1}{2} m v^2 = 180$ J

Total $= U + K = 500$ J

(b) Graph



(c) First determine the time at which the ball hits the ground, using $d_y = 0 + \frac{1}{2} g t^2$, to find it hits at 4 seconds.



1981B1.

(a) constant velocity means $F_{net} = 0$, $F - f_k = ma$ $F - \mu_k mg = 0$ $F - (0.2)(10)(10) = 0$
$F = 20$ N

(b) A change in K would require net work to be done. By the work–energy theorem:
$W_{net} = \Delta K$
$F_{net}\, d = 60$ J
$F_{net}\,(4\text{m}) = 60$ $F_{net} = 15$ N
$F' - f_k = 15$
$F' - 20 = 15$ $F = 35$ N

(c) $F_{net} = ma$
$(15) = (10)\, a$ $a = 1.5\ \text{m/s}^2$

1981B2.

The work to compress the spring would be equal to the amount of spring energy it possessed after compression. After releasing the mass, energy is conserved and the spring energy totally becomes kinetic energy so the kinetic energy of the mass when leaving the spring equals the amount of work done to compress the spring
$W = \frac{1}{2} m v^2 = \frac{1}{2} (3)(10)^2 = 150$ J

1982B3.

Same geometry as in problem 1975B7.

(a) Apply energy conservation top to bottom
$U_{top} = K_{bot}$
$mgh = \frac{1}{2} m v^2$
$mg(R - R\cos\theta) = \frac{1}{2} m v^2$
$$v = \sqrt{2g(R - R\cos\theta)}$$

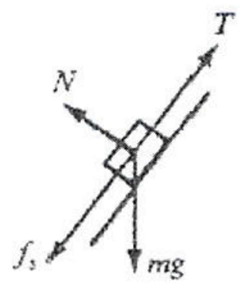
(b) Use $F_{NET(C)} = mv^2 / r$
$F_t - mg = m\,(2g(R - R\cos\theta)) / R$
$1.5\, mg - mg = 2mg(1 - 1\cos\theta)$
$.5 = 2(1 - \cos\theta)$

$2\cos\theta = 1.5 \rightarrow \cos\theta = \frac{3}{4}$

1985B2.

(a) The tension in the string can be found easily by isolating the 10 kg mass. Only two forces act on this mass, the Tension upwards and the weight down (mg) …. Since the systems is at rest, T = mg = 100 N

(b) FBD



(c) Apply $F_{net} = 0$ along the plane. $T - f_s - mg \sin\theta = 0$ $(100\text{ N}) - f_s - (10)(10)(\sin 60)$

$f_s = 13$ N

(d) Loss of mechanical energy = Work done by friction while sliding

First find kinetic friction force Perpendicular to plane $F_{net} = 0$ $F_n = mg\cos\theta$

$F_k = \mu_k F_n = \mu_k mg\cos\theta$

$W_{fk} = f_k d = \mu_k mg\cos\theta\,(d) = (0.15)(10)(10)(\cos(60)) = 15\text{J}$ converted to thermal energy

(e) Using work-energy theorem … The U at the start – loss of energy from friction = K left over

$U - W_{fk} = K$

$mgh - W_{fk} = K$

$mg(d\sin 60) - 15 = K$

$(10)(10)(2)\sin 60 - 15 = K$ $K = 158\text{ J}$

1986B2.

(a) Use projectile methods to find the time. $d_y = v_{iy}t + ½\,a\,t^2$ $h = 0 + g\,t_2 / 2$

$$t = \sqrt{\frac{2h}{g}}$$

(b) v_x at ground is the same as v_x top $V_x = d_x / t$

$$v_x = \frac{D}{\sqrt{\frac{2h}{g}}}$$

multiply top and bottom by reciprocal to rationalize

$$v_x = D\sqrt{\frac{g}{2h}}$$

(c) The work done by the spring to move the block is equal to the amount of K gained by it = K_f
$W = K_f = ½\,m\,v^2 = (½\,M\,(D^2 / (2h/g)) = MD^2\,g / 4h$

(d) Apply energy conservation $U_{sp} = K$

$½\,k\Delta x^2 = ½\,mv^2$ (plug in V from part b) $$v_x = \frac{MD^2 g}{2hX^2}$$

If using $F=k\Delta x$ you have to plug use F_{avg} for the force

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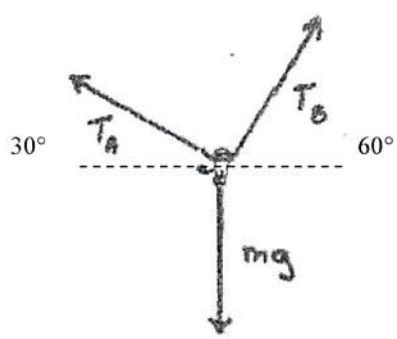
1991B1.

(a) FBD



(b) SIMULTANEOUS EQUATIONS

$F_{net(X)} = 0$ $F_{net(Y)} = 0$

$T_a \cos 30 = T_b \cos 60$ $T_a \sin 30 + T_b \sin 60 - mg = 0$

.... Solve above for T_b and plug into Fnet(y) eqn and solve

$T_a = 24$ N $T_b = 42$ N

(c) Using energy conservation with similar diagram as 1974B1 geometry

$U_{top} = U_p + K_p$

$mgh = ½\,m\,v^2$

$g(L - L\sin\theta) = ½\,v^2$

$(10)(10 - 10\sin 60) = ½\,v^2$ $v = 5.2$ m/s

(d) $F_{net(C)} = mv^2/r$

$F_t - mg = mv^2 / r$ $F_t = m(g + v^2/r)$ $F_t = (5)(9.8+(5.2)^2/10) = 62$ N

1992B1.

(a) $K + U$ $\qquad$ $\frac{1}{2} m v^2 + mgh$ $\qquad$ $\frac{1}{2}(0.1)(6)^2 + (0.1)(9.8)(1.8) = 3.6$ J

(b) Apply energy conservation using ground as h=0

$E_{top} = E_p$

3.6 J = K + U

$3.6 = \frac{1}{2} m v^2 + mgh$

$3.6 = \frac{1}{2}(0.1)(v^2) + (0.1)(9.8)(.2)$ $\qquad$ $v = 8.2$ m/s

(c) Apply net centripetal force with direction towards center as +

i) Top of circle = Ft points down and Fg points down

$F_{net(c)} = mv^2/r$

$Ft + mg = mv^2/r$ $\qquad$ $F_t = mv^2/r - mg$ $\qquad$ $(0.1)(6)^2/(0.8) - (.1)(9.8)$ $\qquad$ $F_t = 3.5$ N

ii) Bottom of circle = Ft points up and Fg points down

$F_{net(c)} = mv^2/r$

$F_t - mg = mv^2/r$ $\qquad$ $F_t = mv^2/r + mg$ $\qquad$ $(0.1)(8.2)^2/(0.8) + (0.1)(9.8)$ $\qquad$ $F_t = 9.5$ N

(d) Ball moves as a projectile.

First find time of fall in y direction

$d_y = v_{iy} t + \frac{1}{2} a t^2$

$(-0.2) = 0 + \frac{1}{2}(-9.8) t^2$

t = .2 sec

Then find range in x direction

$d_x = v_x t$

$d_x = (8.2)(0.2)$

$d_x = 1.6$ m

1996B2.

(a) Use a ruler and known mass. Hang the known mass on the spring and measure the stretch distance Δx. The force pulling the spring F_{sp} is equal to the weight (mg). Plug into $F_{sp} = k\,\Delta x$ and solve for k

(b) Put the spring and mass on an incline and tilt it until it slips and measure the angle. Use this to find the coefficient of static friction on the incline $u_s = \tan\theta$. Then put the spring and mass on a horizontal surface and pull it until it slips. Based on $F_{net} = 0$, we have $F_{spring} - \mu_s\, mg$, Giving $\quad mg = F_{spring} / \mu$.
Since μ is most commonly less than 1 this will allow an mg value to be registered larger than the spring force.

A simpler solution would be to put the block and spring in water. The upwards buoyant force will allow for a weight to be larger than the spring force. This will be covered in the fluid dynamics unit.

1997B1.

(a) The force is constant, so simple $F_{net} = ma$ is sufficient. $(4) = (0.2)\ a$ $a = 20\ m/s^2$

(b) Use $d = v_i t + ½\ a\ t^2$ $12 = (0) + ½\ (20)\ t^2$ $t = 1.1$ sec

(c) $W = Fd$ $W = (4\ N)\ (12\ m) = 48\ J$

(d) Using work energy theorem $W = \Delta K$ $(K_i = 0)$ $W = Kf - Ki$
$W = ½\ m\ v_f^2$

Alternatively, use $v_f^{\ 2} = v_i^2 + 2\ a\ d$ $48J = ½\ (0.2)\ (v_f^2)$ $v_f = 22\ m/s$

(e) The area under the triangle will give the extra work for the last 8 m
$½\ (8)(4) = 16J$ + work for first 12 m (48J) = total work done over 20 m = 64 J

Again using work energy theorem $W = ½\ m\ v_f^2$ $64\ J = ½\ (0.2)\ v_f^2$ $v_f = 25.3\ m/s$

Note: if using F = ma and kinematics equations, the acceleration in the last 8 m would need to be found using the average force over that interval.

1999B1.

(a) Plug into $g = GM_{planet} / r_{planet}^{\ 2}$ lookup earth mass and radius
$g_{mars} = 3.822\ m/s^2$ to get it in terms of g_{earth} divide by 9.8 $g_{mars} = 0.39\ g_{earth}$

(b) Since on the surface, simply plug into $F_g = mg = (11.5)(3.8) = 44\ N$

(c) On the incline, $F_n = mg \cos\theta = (44) \cos (20) = 41\ N$

(d) moving at constant velocity → $F_{net} = 0$

(e) $W = P\ t$ $(5.4\text{x}10^5\ J) = (10\ W)\ t$ $t = 54000$ sec
$d = v\ t$ $(6.7\text{x}10^{-3})(54000\ s)$ $d = 362\ m$

(f) $P = Fv$ $(10) = F\ (6.7\text{x}10^{-3})$ $F_{push} = 1492.54\ N$ total pushing force used
* (.0001) use for drag
→ $F_{drag} = 0.15\ N$

2002B2.

(a) From graph U = 0.05 J

(b) Since the total energy is 0.4 J, the farthest position would be when all of that energy was potential spring energy. From the graph, when all of the spring potential is 0.4 J, the displacement is 10 cm

(c) At –7 cm we read the potential energy off the graph as 0.18 J. Now we use energy conservation.
$ME = U_{sp} + K$ $0.4J = 0.18\ J + K$ → $K = 0.22\ J$

(d) At x=0 all of the energy is kinetic energy $K = ½\ m\ v^2$ $0.4 = ½\ (3)\ v^2$ $v = 0.5\ m/s$

(e) The object moves as a horizontally launched projectile when it leaves.

First find time of fall in y direction
$d_y = v_{iy} t + ½\ a\ t^2$
$(-0.5) = 0 + ½\ (-9.8)\ t^2$
$t = 0.3$ sec

Then find range in x direction
$d_x = v_x\ t$
$d_x = (0.5)(0.3)$
$d_x = 0.15\ m$

2004B1.

(a) i) fastest speed would be the lowest position which is the bottom of the first hill where you get all sick and puke your brains out.

ii) Applying energy conservation from the top of the hill where we assume the velocity is approximately zero we have

$U_{top} = K_{bottom}$

$mgh = \frac{1}{2} m v^2$ $\qquad$ $(9.8)(90) = \frac{1}{2} v^2$ $\qquad$ $v = 42$ m/s

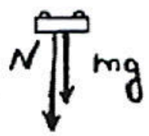
(b) Again applying energy conservation from the top to position B

$U_{top} = K_b + U_b$

$mgh = \frac{1}{2} m v_B{}^2 + mgh_B$

$(9.8)(90) = \frac{1}{2} v_B{}^2 + (9.8)(50)$ $\qquad$ $v_B = 28$ m/s

(c) i) FBD



ii) $mg = (700)(9.8) = 6860$ N

$F_{net(C)} = mv^2/r$

$F_n + mg = mv^2/r$

$F_n = mv^2/r - mg \;= m(v^2/r - g) \;= (700)(28^2/20 - 9.8) = 20580$ N

(d) The friction will remove some of the energy so there will not be as much Kinetic energy at the top of the loop. In order to bring the KE back up to its original value to maintain the original speed, we would need less PE at that location. A lower height of the loop would reduce the PE and compensate to allow the same KE as before. To actually modify the track, you could flatten the inclines on either side of the loop to lower the height at B.

B2004B1.

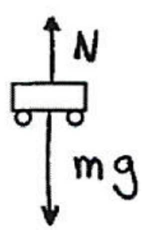
(a) set position A as the h=0 location so that the PE=0 there.

Applying energy conservation with have

$U_{top} + K_{top} = K_A$ $\qquad$ $mgh + \frac{1}{2} m v^2 = \frac{1}{2} m v_A{}^2$

$(9.8)(0.1) + \frac{1}{2}(1.5)^2 = \frac{1}{2} v_A{}^2$ $\qquad$ $v_A = 2.05$ m/s

(b) FBD



(c) $F_{net(C)} = mv^2/r$

$mg - F_N = mv^2/r$

$Fn = mg - mv^2/r \;= m(g - v^2/r) = (0.5)(9.8 - 2.05^2/0.95) \;= 2.7$ N

(c) To stop the cart at point A, all of the kinetic energy that would have existed here needs to be removed by the work of friction which does negative work to remove the energy.

$W_{fk} = -K_A$

$W_{fk} = -\frac{1}{2} m v_A{}^2 = -\frac{1}{2}(0.5)(2.05^2) = -1.1$ J

(d) The car is rolling over a hill at point A and when F_n becomes zero the car just barely loses contact with the track. Based on the equation from part (c) the larger the quantity (mv^2/r) the more likely the car is to lose contact with the track (since more centripetal force would be required to keep it there) … to increase this quantity either the velocity could be increased or the radius could be decreased. To increase the velocity of the car, make the initial hill higher to increase the initial energy. To decrease the radius, simply shorten the hill length.

B2005B2.

FBD i) ii)

(b) Apply energy conservation?

$U_{top} = K_{bottom}$

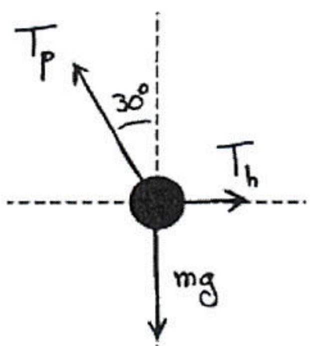
$mgh = \frac{1}{2} m v^2$ $\quad (9.8)(.08) - \frac{1}{2} v^2$ $\quad v = 1.3$ m/s

(c) $F_{net(c)} = mv^2/r$

$F_t - mg = mv^2/r$ $\quad F_t = mv^2/r + mg$ $\quad (0.085)(1.3)^2/(1.5) + (0.085)(9.8)$ $\quad F_t = 0.93$ N

2005B2.

(a) FBD



(b) Apply

$F_{net(X)} = 0$

$T_P \cos 30 = mg$

$T_P = 20.37$ N

$F_{net(Y)} = 0$

$T_P \sin 30 = T_H$

$T_H = 10.18$ N

(c) Conservation of energy – Diagram similar to 1975B7.

$U_{top} = K_{bottom}$

$mgh = \frac{1}{2} m v^2$

$g(L - L \cos \theta) = \frac{1}{2} v^2$

$(10)(2.3 - 2.3 \cos 30) = \frac{1}{2} v^2$ $\quad v_{bottom} = 2.5$ m/s

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B2006B2.

(a) Apply energy conservation

$U_{top} = K_{bottom}$

$mgh = \frac{1}{2} m v^2$ $\quad Mgh = \frac{1}{2} (M) (3.5v_o)^2$ $\quad h = 6.125\ v_o^2 / g$

(b) $W_{NC} = \Delta K \ (K_f - K_i) \quad K_f = 0$

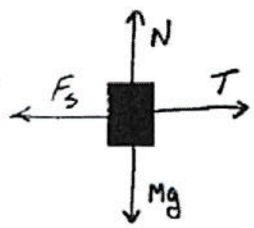
$- f_k\ d = 0 - \frac{1}{2} (1.5M)(2v_o)^2$

$\mu_k (1.5\ M)\ g\ (d) = 3Mv_o^2$ $\quad \mu_k = 2v_o^2 / gD$

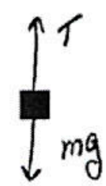
2006B1.

(a) FBD

M = 8.0 kg



m = 4.0 kg



(b) Simply isolating the 4 kg mass at rest. $F_{net} = 0$ $\quad F_t - mg = 0$ $\quad F_t = 39$ N

(c) Tension in string is uniform throughout, now looking at the 8 kg mass,
$F_{sp} = F_t = k\Delta x$ $\quad 39 = k\,(0.05)$ $\quad k = 780$ N/m

(d) 4 kg mass is in free fall. $D = v_it + \frac{1}{2} g\, t^2$ $\quad -0.7 = 0 + \frac{1}{2}(-9.8)t^2$ $\quad t = 0.38$ sec

(e) The 8 kg block will be pulled towards the wall and will reach a maximum speed when it passes the relaxed length of the spring. At this point all of the initial stored potential energy is converted to kinetic energy
$U_{sp} = K$ $\quad \frac{1}{2} k\, \Delta x^2 = \frac{1}{2} mv^2$ $\quad \frac{1}{2}(780)(0.05) = \frac{1}{2}(8)\, v^2$ $\quad v = 0.49$ m/s

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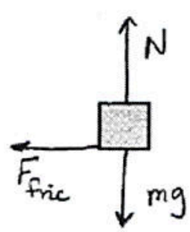
B2008B2.

(a) $d = v_it + \frac{1}{2} a\, t^2$ $\quad (55) = (25)(3) + \frac{1}{2} a\, (3)^2$ $\quad a = -4.4$ m/s^2

(b) FBD



(c) using the diagram above and understanding that the static friction is actually responsible for decelerating the box to match the deceleration of the truck, we apply F_{net}
$F_{net} = ma$
$-f_s = -\mu_s F_n = ma$ $\quad -\mu_s\, mg = ma$ $\quad -\mu_s = a/g$ $\quad -\mu_s = -4.4 / 9.8$ $\quad \mu_s = 0.45$

Static friction applied to keep the box at rest relative to the truck bed.

(d) Use the given info to find the acceleration of the truck $\quad a = \Delta v / t = 25/10 = 2.5$ m/s^2
To keep up with the trucks acceleration, the crate must be accelerated by the spring force, apply F_{net}
$F_{net} = ma$ $\quad F_{sp} = ma$ $\quad k\Delta x = ma$ $\quad (9200)(\Delta x) = (900)(2.5)$ $\quad \Delta x = 0.24$ m

(e) If the truck is moving at a constant speed the net force is zero. Since the only force acting directly on the crate is the spring force, the spring force must also become zero therefore the Δx would be zero and is **LESS** than before. Keep in mind the crate will stay on the frictionless truck bed because its inertia will keep it moving forward with the truck (remember you don't necessarily need forces to keep things moving)

2008B2.

(a) In a connected system, we must first find the acceleration of the system as a whole. The spring is internal when looking at the whole system and can be ignored.

$F_{net} = ma$ $(4) = (10)\,a$ $a = 0.4\ m/s^2$ → the acceleration of the whole system and also of each individual block when looked at separate

Now we look at just the 2 kg block, which has only the spring force acting on its FBD horizontal direction.

$F_{net} = ma$ $F_{sp} = (2)(.4)$ $F_{sp} = 0.8\ N$

(b) Use $F_{sp} = k\Delta x$ $0.8 = (80)\,\Delta x$ $\Delta x = 0.01\ m$

(c) Since the same force is acting on the same total mass and $F_{net} = ma$, the acceleration is the same

(d) The spring stretch will be MORE. This can be shown mathematically by looking at either block. Since the 8 kg block has only the spring force on its FBD we will look at that one.

$F_{sp} = ma$ $k\Delta x = ma$ $(80)(\Delta x) = (8)(0.4)$ $\Delta x = 0.04\ m$

(e) When the block A hits the wall it instantly stops, then block B will begin to compress the spring and transfer its kinetic energy into spring potential energy. Looking at block B energy conservation:

$K_b = U_{sp}$ $\frac{1}{2}\, m\, v_b^2 = \frac{1}{2}\, k\, \Delta x^2$ $(8)(0.5)^2 = (80)\Delta x^2$ $\Delta x = 0.16\ m$

2009B1.

(a) Apply energy conservation. All of the spring potential becomes gravitational potential

$U_{sp} = U$

$\frac{1}{2} k \Delta x^2 = mgh$ $\qquad$ $\frac{1}{2} k x^2 = mgh$ $\qquad$ $h = kx^2 / 2mg$

(b) You need to make a graph that is of the form y = m x, with the slope having "k" as part of it and the y and x values changing with each other. Other constants can also be included in the slope as well to make the y and x variables simpler. h is dependent on the different masses used so we will make h our y value and use m as part of our x value. Rearrange the given equation so that is it of the form y = mx with h being y and mass related to x.

We get $\qquad$ y = m x

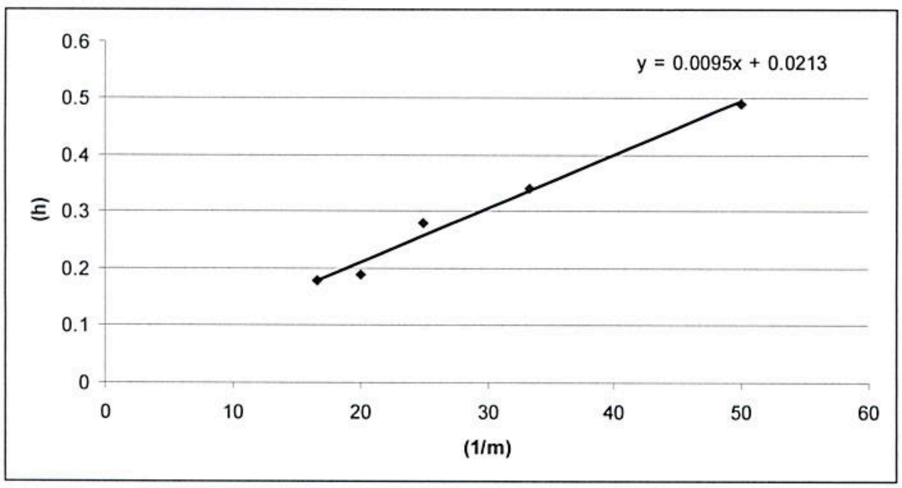
$$h = \left(\frac{kx^2}{2g}\right)\frac{1}{m}$$

so we use h as y and the value 1/m as x and graph it.

(note: we lumped all the things that do not change together as the constant slope term. Once we get a value for the slope, we can set it equal to this term and solve for k)

1/m	m (kg)	h (m)
50	0.020	0.49
33.33	0.030	0.34
25	0.040	0.28
20	0.050	0.19
16.67	0.060	0.18
X values		Y values

(c) Graph



(d) The slope of the best fit line is 0.01

We set this slope equal to the slope term in our equation, plug in the other known values and then solve it for k

$$0.01 = \left(\frac{kx^2}{2g}\right)$$

$$0.01 = \left(\frac{k(0.02)^2}{2(9.8)}\right)$$

Solving gives us $\quad$ k = 490 N/m

(e) - Use a stopwatch, or better, a precise laser time measurement system (such as a photogate), to determine the time it takes the toy to leave the ground and raise to the max height (same as time it takes to fall back down as well). Since its in free fall, use the down trip with v_i=0 and apply $d = \frac{1}{2} g t^2$ to find the height.

- Or, videotape it up against a metric scale using a high speed camera and slow motion to find the max h.

C1973M2

(a) Apply work-energy theorem
$W_{nc} = \Delta ME$
$W_{fk} = \Delta K \quad (K_f - K_i) \qquad K_f = 0$
$-f_k\, d = -\frac{1}{2} m v_i^2 \qquad -f_k\,(0.12) = -\frac{1}{2}\,(0.030)\,(500)^2 \qquad f_k = 31250\ \text{N}$

(b) Find find acceleration $\qquad -f_k = ma \qquad -(31250) = (0.03)\,a \qquad a = -1.04\text{x}10^6\ \text{m/s}^2$

Then use kinematics $\qquad v_f = v_i + at \qquad 0 = 500 + (-1.04\text{x}10^6)\,t \qquad t = 4.8\text{x}10^{-4}\ \text{sec}$

C1982M1

(a) Apply energy conservation, set the top of the spring as h=0, therefore H at start = L$\sin\theta$ = 6 sin30 = 3 m

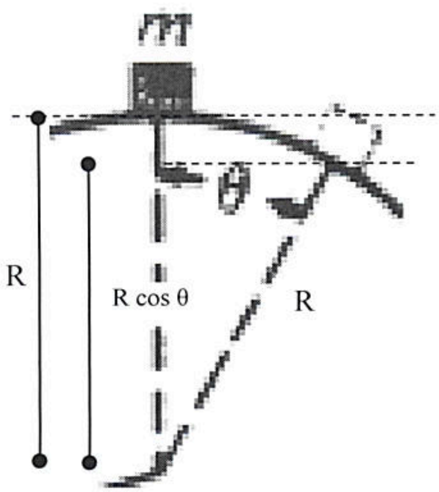
$U_{top} = K_{bot} \quad mgh = \frac{1}{2} mv^2 \qquad (9.8)(3) = \frac{1}{2}(v^2) \qquad v = 7.67\ \text{m/s}$

(b) Set a new position for h=0 at the bottom of the spring. Apply energy conservation comparing the h=0 position and the initial height location. Note: The initial height of the box will include both the y component of the initial distance along the inclined plane plus the y component of the compression distance Δx.
$h = L\sin\theta + \Delta x \sin\theta$

$U_{top} = U_{sp}(\text{bot})$
$mgh = \frac{1}{2} k\,\Delta x^2$
$mg(L\sin\theta + \Delta x\sin\theta) = \frac{1}{2} k\,\Delta x^2$
$(20)(9.8)(6\sin 30 + 3\sin 30) = \frac{1}{2} k\,(3)^2 \qquad k = 196\ \text{N/m}$

(c) The speed is NOT a maximum when the block first hits the spring. Although the spring starts to push upwards against the motion of the block, the upwards spring force is initially less than the x component of the weight pushing down the incline (F_{gx}) so there is still a net force down the incline which makes the box accelerate and gain speed. This net force will decrease as the box moves down and the spring force increases. The maximum speed of the block will occur when the upwards spring force is equal in magnitude to the force down the incline such that Fnet is zero and the box stops accelerating down the incline. Past this point, the spring force becomes greater and there is a net force acting up the incline which slows the box until it eventually and momentarily comes to rest in the specified location.

C1983M3.



$h = R - R\cos\theta = R\,(1 - \cos\theta)$

i) $K_2 = U_{top}$
$K_2 = mg(R\,(1 - \cos\theta))$

ii) From, $K = \frac{1}{2} m v^2 = mgR\,(1 - \cos\theta) \;\ldots\; v^2 = 2gR\,(1 - \cos\theta)$

Then $a_c = v^2 / R = \;\; 2g\,(1 - \cos\theta)$

C1985M1

(a) We use $F_{net} = 0$ for the initial brink of slipping point. $F_{gx} - f_k = 0$ $mg \sin\theta = \mu_s(F_n)$

$mg \sin\theta = \mu_s\, mg \cos\theta$ $\mu_s = \tan\theta$

(b) Note: we cannot use the friction force from part a since this is the static friction force, we would need kinetic friction. So instead we must apply W_{nc} = energy loss = $\Delta K + \Delta U + \Delta U_{sp}$. ΔK is zero since the box starts and ends at rest, but there is a loss of gravitational U and a gain of spring U so those two terms will determine the loss of energy, setting final position as h=0. Note that the initial height would be the y component of the total distance traveled (d+x) so h= (d+x)sin θ

$U_f - U_i + U_{sp(F)} - U_{sp(i)}$

$0 - mgh + \frac{1}{2} k\Delta x^2 - 0$ $\frac{1}{2} kx^2 - mg(d+x)\sin\theta$

(c) To determine the coefficient of kinetic friction, plug the term above back into the work-energy relationship, sub in –Work of friction as the work term and then solve for μ_k

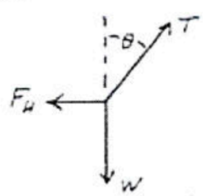
$W_{NC} = \frac{1}{2} kx^2 - mg(d+x)\sin\theta$ $-f_k(d+x) = \frac{1}{2} kx^2 - mg(d+x)\sin\theta$

$-\mu_k\, mg \cos\theta\, (d+x) = \frac{1}{2} kx^2 - mg(d+x)\sin\theta$

$\mu_k = [mg(d+x)\sin\theta - \frac{1}{2} kx^2] / [mg\,(d+x)\cos\theta]$

C1987M1

(a)



$F_{net(y)} = 0$

$T \cos\theta - W = 0$ $T = W / \cos\theta$

(b) Apply SIMULTANEOUS EQUATIONS

$F_{net(y)} = 0$ $F_{net(x)} = 0$

$T \cos\theta - W = 0$ $T \sin\theta - F_h = 0$

Sub T into X equation to get F_h $F_h = W \tan\theta$

(c) Using the same geometry diagram as solution 1975B7 solve for the velocity at the bottom using energy conservation

$U_{top} = K_{bot}$

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

$$v = \sqrt{2g(L - L\cos\theta)}$$

$$v = \sqrt{2gL(1 - \cos\theta)}$$

Then apply $F_{NET(C)} = mv^2 / r$

$(T - W) = m(2gL(1 - \cos\theta)) / L$

$T = W + 2mg - 2mg \cos\theta$

$T = W + 2W - 2W \cos\theta = W(3 - 2\cos\theta)$

C1988M2

(a) The graph is one of force vs Δx so the slope of this graph is the spring constant. Slope = 200 N/m

(b) Since there is no friction, energy is conserved and the decrease in kinetic energy will be equal to the gain in spring potential $|\Delta K| = U_{sp(f)} = \frac{1}{2} k\,\Delta x^2 = \frac{1}{2}(200)(0.1)^2 = 1$ J.

Note: This is the same as the area under the line since the area would be the work done by the conservative spring force and the work done by a conservative force is equal to the amount of energy transferred.

(c) Using energy conservation. $K_i = U_{sp(f)}$ $\frac{1}{2} mv_o^2 = 1$ J $\frac{1}{2}(5)\, v_o^2 = 1$ $v_o = 0.63$ m/s

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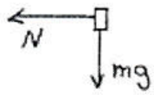
C1989M1

(a) Apply energy conservation from point A to point C setting point C as h=0 location
(note: to find h as shown in the diagram, we will have to add in the initial 0.5m below h=0 location)

$U_A = K_C$ $mgh_a = \frac{1}{2} m v_c^2$ $(0.1)(9.8)(h_a) = \frac{1}{2}(0.1)(4)^2$ $h_a = 0.816\text{m}$
$h = h_a + 0.5 \text{ m} = 1.32 \text{ m}$

(b)



(c) Since the height at B and the height at C are the same, they would have to have the same velocities $v_b = 4$ m/s

(d) $F_{net(c)} = mv^2 / r$ $F_n = (0.1)(4)^2/(0.5) = 3.2 \text{ N}$

(e) Using projectile methods … $V_{iy} = 4\sin 30 = 2$ m/s Then $v_{fy}^2 = v_{iy}^2 + 2 a d_y$
$(0) = (2)^2 + 2(-9.8)(d_y)$ $d_y = 0.2$
$h_{max} = d_y$ + initial height $= 0.7$ m

Alternatively you can do energy conservation setting h=0 at point C. Then $K_c = U_{top} + K_{top}$ keeping in mind that at the top the block has a kinetic energy related to its velocity there which is the same as v_x at point C.

(f) Since the block will have the same total energy at point C as before but it will lose energy on the track the new initial height h is larger than before. To find the loss of energy on the track, you can simply subtract the initial energies in each case. $U_{new} - U_{old} = mgh_{net} - mgh_{old}$ $(0.1)(9.8)(2-1.32) = 0.67$ J lost.

C1989M3

(a) Apply energy conservation from start to top of spring using h=0 as top of spring.
$U = K$ $mgh = \frac{1}{2} m v^2$ $(9.8)(0.45) = \frac{1}{2} v^2$ $v = 3$ m/s

(b) At equilibrium the forces are balances $F_{net} = 0$ $F_{sp} = mg = (2)(9.8) = 19.6$ N

(c) Using the force from part b, $F_{sp} = k\,\Delta x$ $19.6 = 200\,\Delta x$ $\Delta x = 0.098$ m

(d) Apply energy conservation using the equilibrium position as h = 0. (Note that the height at the start position is now increased by the amount of Δx found in part c $h_{new} = h + \Delta x = 0.45 + 0.098 = 0.548$ m)
$U_{top} = U_{sp} + K$
$mgh = \frac{1}{2} k\,\Delta x^2 + \frac{1}{2} mv^2$ $(2)(9.8)(0.548) = \frac{1}{2}(200)(0.098)^2 + \frac{1}{2}(2)(v^2)$ $v = 3.13$ m/s

(e) This is the maximum speed because this was the point when the spring force and weight were equal to each other and the acceleration was zero. Past this point, the spring force will increase above the value of gravity causing an upwards acceleration which will slow the box down until it reaches its maximum compression and stops momentarily.

C1990M2

(a) Energy conservation, $K_{bot} = U_{top}$ $\frac{1}{2} m v^2 = mgh$ $\frac{1}{2}(v_o^2) = gh$ $h = v_o^2 / 2g$

(b) Work-Energy theorem. $W_{nc} = \Delta K + \Delta U$ $(U_i = 0, K_f = 0)$
$-f_k d = (mgh - 0) + (0 - \frac{1}{2} m v_o^2)$ $-(\mu_k mg\cos\theta)\, h_2 / \sin\theta = mgh_2 - \frac{1}{2} mv_o^2$

$\mu\, mg\cos\theta\, h_2 / \sin\theta + mgh_2 = \frac{1}{2} mv_o^2$ $h_2(\mu g\cos\theta / \sin\theta + g) = \frac{1}{2} v_o^2$
$h_2 = v_o^2 / (2g(\mu\cot\theta + 1))$

C1991M1

(a) Apply energy conservation.

$K_{bottom} = U_p + K_p$ $\quad$ $\frac{1}{2} mv_{bot}^2 = mgh_p + K_p$

$\frac{1}{2}\, 3m (v_o/3)^2 = 3mg(r) + K_p$ $\quad$ $K_p = mv_o^2/6 - 3mgr$

(b) The minimum speed to stay in contact is the limit point at the top where F_n just becomes zero. So set $F_n=0$ at the top of the loop so that only mg is acting down on the block. Then apply $F_{net(C)}$

$F_{net(C)} = mv^2 / r$ $\quad$ $3mg = 3m\, v^2 /r$ $\quad$ $v = \sqrt{rg}$

(c) Energy conservation, top of loop to bottom of loop

$U_{top} + K_{top} = K_{bot}$

$mgh + \frac{1}{2} m\, v_{top}^2 = \frac{1}{2} m\, v_{bot}^2$ $\quad$ $g(2r) + \frac{1}{2} (\sqrt{rg})^2 = \frac{1}{2} (vo')^2$ $\quad$ $v_o' = \sqrt{5gr}$

C1993M1

- since there is friction on the surface the whole time, this is not an energy conservation problem, use work-energy.

(a) $U_{sp} = \frac{1}{2} k\, \Delta x^2 = \frac{1}{2} (400)(0.5)^2 = 50$ J

(b) Using work-energy

$W_{nc} = \Delta U_{sp} + \Delta K = (U_{sp(f)} - U_{sp(i)}) + (K_f - K_i)$

$-f_k d = (0 - 50\text{J}) + (\frac{1}{2} m\, v_f^2 - 0)$

$-\mu\, mg\, d = \frac{1}{2} mv_f^2 - 50$

$-(0.4)(4)(9.8)(0.5) = \frac{1}{2} (4)(v_c^2) - 50$ $\quad$ $v_c = 4.59$ m/s

(c) $W_{nc} = (K_f - K_i)$

$-f_k d = (0 - \frac{1}{2} m\, v_i^2)$ $\quad$ $-\mu\, mg\, d = -\frac{1}{2} m\, v_i^2$ $\quad$ $(0.4)(6)(9.8)\, d = \frac{1}{2} (6)(3)^2$ $\quad$ $d = 1.15$ m

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C2002M2

(a) Energy conservation, potential top = kinetic bottom $\quad$ $v = \sqrt{2gh}$

(b) Energy conservation, potential top = spring potential $\quad$ $U=U_{sp}$ $\quad$ $(2m)gh = \frac{1}{2} k\, x_m^2$

$$x_m = 2\sqrt{\frac{mgh}{k}}$$

C2004M1

(a) Energy conservation with position B set as h=0. $U_a = K_b$ $\quad$ $v_b = \sqrt{2gL}$

(b) Forces at B, F_t pointing up and mg pointing down. Apply $F_{net(c)}$

$F_{net(C)} = mv_b^2 / r$ $\quad$ $F_t - mg = m(2gL) / L$ $\quad$ $F_t = 3mg$

(c) Projectile. First find time to travel from B to D using the y direction equations

$d_y = v_{iy}t + \frac{1}{2} g\, t^2$ $\quad$ $L = 0 + gt^2 / 2$

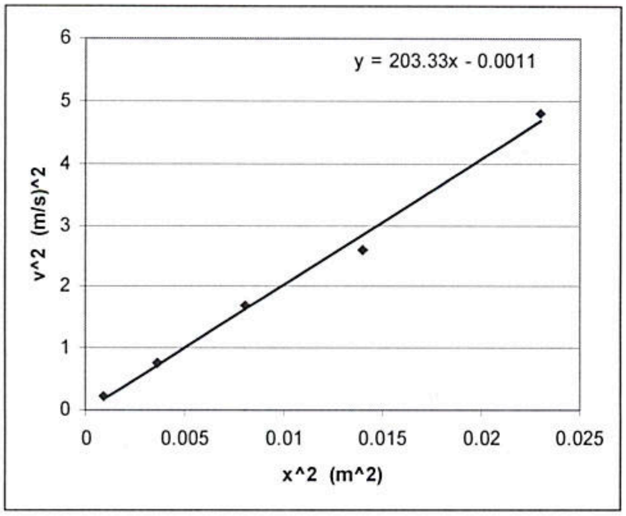
$t = \sqrt{\frac{2L}{g}}$ $\quad$ Then use $v_x = d_x / t$ $\quad$ $d_x = v'\sqrt{\frac{2L}{g}}$ $\quad$ total distance $\quad$ $x = v'\sqrt{\frac{2L}{g}} + L$

total distance includes the initial horizontal displacement L so it is added to the range

C2007M3

(a) Spring potential energy is converted into kinetic energy $\frac{1}{2} kx^2 = \frac{1}{2} mv^2$

(b) (c) i)



ii) using the equation above and rearrange to the form $y = m\,x$ with v^2 as y and x^2 as x

$$y = m \quad x$$
$$v^2 = (k/m)\, x^2$$

Slope = 200 = k /m

200 = (40) / m

m = 0.2 kg

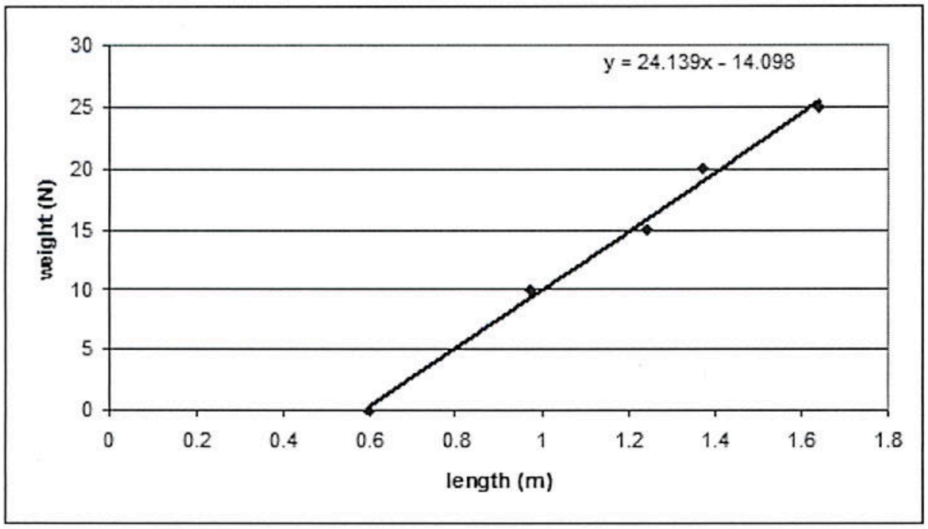
(d) Now you start with spring potential and gravitational potential and convert to kinetic. Note that at position A the height of the glider is given by h + the y component of the stretch distance x. $h_{initial} = h + x \sin\theta$

$U + U_{sp} = K$

$mgh + \frac{1}{2} k\, x^2 = \frac{1}{2} m\, v^2 \qquad mg(h + x \sin\theta) + \frac{1}{2} kx^2 = \frac{1}{2} mv^2$

C2008M3

(a)



(b) The slope of the line is $F / \Delta x$ which is the spring constant. Slope = 24 N/m

(c) Apply energy conservation. $U_{top} = U_{sp}$(bottom).
Note that the spring stretch is the final distance – the initial length of the spring. $1.5 - 0.6 = 0.90$ m

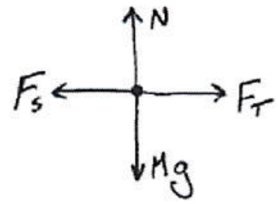
$mgh = \frac{1}{2} k \Delta x^2$ $m(9.8)(1.5) = \frac{1}{2}(24)(0.9)^2$ $m = 0.66$ kg

(d) i) At equilibrium, the net force on the mass is zero so $F_{sp} = mg$ $F_{sp} = (0.66)(9.8)$ $F_{sp} = 6.5$ N

ii) $F_{sp} = k \Delta x$ $6.5 = (24) \Delta x$ $\Delta x = 0.27$ m

Supplemental

(a)



(b) $F_{net} = 0$ $F_t = F_{sp} = k\Delta x$ $\Delta x = F_t / k$

(c) Using energy conservation $U_{sp} = U_{sp} + K$ note that the second postion has both K and U_{sp} since the spring still has stretch to it.

$\frac{1}{2} k \Delta x^2 = \frac{1}{2} k\Delta x_2{}^2 + \frac{1}{2} mv^2$
$k (\Delta x)^2 = k(\Delta x/2)^2 + Mv^2$

$\frac{3}{4} k(\Delta x)^2 = Mv^2$, plug in Δx from (b) … $\frac{3}{4} k(F_t/k)^2 = Mv^2$ $$v = \frac{F_t}{2}\sqrt{\frac{3}{kM}}$$

(d) The forces acting on the block in the x direction are the spring force and the friction force. Using left as + we get
$F_{net} = ma$ $F_{sp} - f_k = ma$
From (b) we know that the initial value of F_{sp} is equal to F_t which is an acceptable variable so we simply plug in F_t for F_{sp} to get $F_t - \mu_k mg = ma$ $\rightarrow a = F_t / m - \mu_k g$