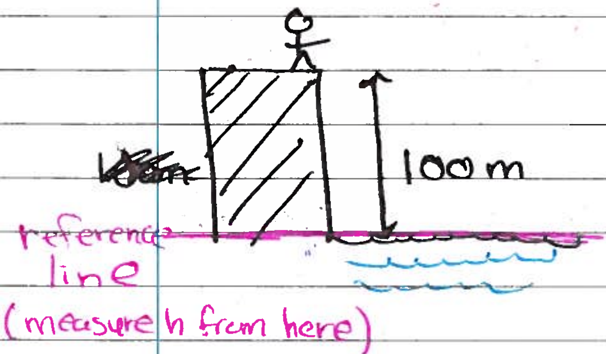
Conservation of Energy

Nov 8, 2012

Consider a diver of mass 70kg. He is on a diving board 100m high. Find his kinetic energy and potential energy at the top and bottom



At top

$v_1 = 0$ [he starts from rest]

$h = 100\text{ m}$

$m = 70\text{kg}$

$E_k = \frac{1}{2}mv_1^2 = 0\text{ J}$ $\quad E_g = mgh = (70)(9.8)(100)$
$= 68600\text{ J}$

$$\boxed{\begin{aligned} E_{total} &= 0 + 68600\text{ J} \\ &= 68600\text{ J} \end{aligned}}$$

At bottom

$$\left.\begin{aligned} v_1 &= 0 \\ v_2 &= ? \\ \Delta d &= 100\text{m} \\ a = g &= 9.8\text{ m/s}^2 \end{aligned}\right\} \text{use famous five to find his speed}$$

$$v_2^2 = v_1^2 + 2ad$$
$$= 0^2 + 2(9.8)(100)$$
$$v_2 = \sqrt{1960} = 44.27\text{ m/s}$$

$h = 0$

$$E_g = mgh$$
$$= (70)(9.8)(0)$$
$$= 0\text{ J}$$

$$E_k = \frac{1}{2}mv^2$$
$$= \frac{1}{2}(70)(44.27)^2 \quad \sqrt{1960}$$
$$= \frac{1}{2}(70)(\sqrt{1960})^2$$
$$= \frac{1}{2}(70)(1960)$$
$$= 68600$$

$$\boxed{\begin{aligned} E_{Tot} &= E_g + E_k \\ &= 0 + 68600 \end{aligned}}$$

→ the total is the same! This is not a coincidence

Mechanical Energy: The sum of all the potential and kinetic energy. $E_m = E_k + E_g$

[For us the potential energy is just gravitational potential. In grade 12 you will see other kinds like elastic or chemical.]

↳ in a system where friction does not act mechanical energy is constant!

→ but energy in total is actually always conserved

Law of Conservation of Energy
- the total amount of energy in the universe is conserved. New energy cannot be created or destroyed it is just transferred from one form to the other.

this is a * big * deal in physics.

we can use this law to solve lots of problems in physics. Kinematics problems become a lot easier if you use

$$\boxed{E_{tot}^{A} = E_{tot}^{B}}$$

↑ the total energy at any point A = the tot energy at B

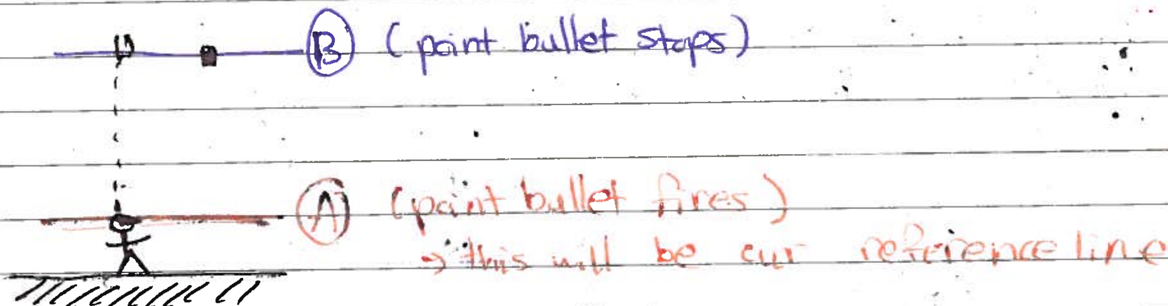
for us

$$E_K^A + E_g^A = E_K^B + E_g^B$$

Sample problem 1: Nov 8, 2012

kinematics?

you shoot a bullet straight up in the air at 896 m/s. How far up will the bullet travel neglecting air resistance.



$$E_{tot}^{A} = E_{tot}^{B}$$

$$\boxed{\frac{1}{2}\cancel{m}v_A^2 + \cancel{m}gh_A = \frac{1}{2}\cancel{m}v_B^2 + \cancel{m}gh_B}$$

note mass cancels out!

$$\boxed{\frac{1}{2}v_A^2 + gh_A = \frac{1}{2}v_B^2 + gh_B}$$

$v_A = 896\,m/s$

$h_A = 0$ [this is our height from ref line to A]

$v_B = 0\,m/s$

$h_B = h$ [we don't know this]

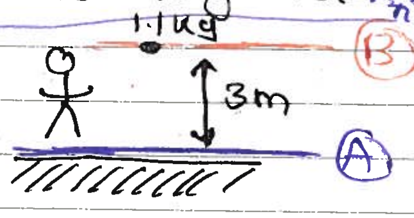
$$\frac{1}{2}(896)^2 + \cancel{(9.8)(0)} = \cancel{\frac{1}{2}v_B^2}^{\,0} + (9.8)(h)$$

$$h = \frac{\frac{1}{2}(896)^2}{9.8} = 40960$$

Sample problem 2

a 1.1 kg camera falls out of a man's hand and falls 3m to the ground.

a.) find the gravitational potential energy at top [relative to ground]
b.) find kinetic energy at the bottom
c.) Speed at which it hits the ground ***



a.) $E_g = mgh$

$= (1.1)(9.8)(3)$

$= 32.34\ J$ $E_k = 0$ at A

b.) $E_k = \frac{1}{2}mv^2$ $E_g = 0$ at B

we get "stuck" here

$E_{tot}^{Ⓐ} = E_{tot}^{Ⓑ}$

$E_k^{Ⓐ} + \cancel{E_g^{Ⓐ}} = \cancel{E_k^{Ⓑ}} + E_g^{Ⓑ}$

*** note: do not "skip" steps and assume one of your energies is zero. It may not be. Always start with this line ***

$E_k^{Ⓐ} = E_g^{Ⓑ} = 32.34\ J$

c.) $E_k^A = 32.34\ J$, $m = 1.1\ kg$

$E_k^A = \frac{1}{2}mv^2$

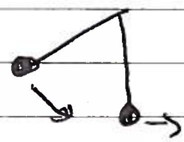
$v^2 = \frac{2E_k^A}{m}$ $v = \sqrt{\frac{2E_k^A}{m}} = \sqrt{\frac{2(32.34)}{1.1}} = 7.67\ m/s$

*** you can find velocity without finding Ek and Eg first! the mass of the camera does not affect the speed.

Conservation of Energy

Nov 8, 2012

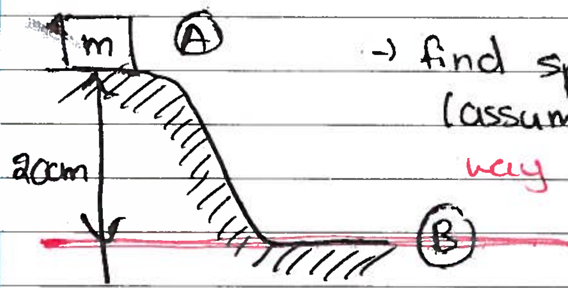
pendulum: gravitational potential energy is converted to kinetic energy.



If energy is always conserved why does the pendulum stop? Is this violating our law?

It is not! Although mechanical energy is being lost, the total energy is constant [Friction is generating heat energy.]

Sample problem 3: one without mass



→ find speed at bottom of hill (assuming it is frictionless — that way mechanical energy is also conserved.)

reference line

$$E_{tot}^{A} = E_{tot}^{B}$$

$$\cancel{E_k^{A}}^{\,0} + E_g^{A} = E_k^{B} + \cancel{E_g^{B}}^{\,0}$$

$$\cancel{m} g h_a = \frac{1}{2}\cancel{m} V_a^2$$

$$V_a^2 = 2gh_a$$

$$V_a = \sqrt{2gh_a} = \sqrt{2(9.8)(200)} = 62.6 \text{ m/s}$$