Grade 11 Notes April 13th to 17th, 2020

Hello everyone. Happy Easter. Included in this download are the notes I would like you to review for this week. They include

1. Universal Force of Gravity

2. Types of Energy and Work

3. Power

4. Kinetic and Gravitational Potential Energy

You don't have to do all in one day. Space it out over the week.

On Thursday this week I will post an assignment that will test you on these concepts. This assignment will be due the next Wednesday April 22th.

Don't forget to do the assignment from last week on forces. It is due Wednesday April 15th. Questions email me.

Any questions email me please. I have uploaded a zipped pdf version of the textbook to my website www.misstakken.weebly.com if you don't have yours. Have a good week.

1. Universal Force of Gravity

Last week we discuss the force of gravity found on Earth. However, this value, calculated using Fg=mg where g = 9.8 m/s^2, only works on or near the surface of the Earth. Say within 0 to 100 km. After that the value changes because g changes. The further an object gets from the surface the less the gravitational field constant (acceleration due to gravity) will be. This formula is only for a mass and the Earth as our two objects.

But this formula does not help us determine the force of gravity between any two masses in the universe. **Gravity is the force of attraction between any two masses.** That is the formal definition.

The formula to determine the force of gravity anywhere and with any two masses is

$$\mathbf{F_g = (Gm_1m_2)/r^2}$$

where F_g is the force of gravity (or weight) in Newtons (N)

m_1 is the mass of the first object in kilograms (kg)

m_2 is the mass of the second object in kilograms (kg)

r is the distance separating the two objects from centre to centre in meters (m)

G is the universal gravitational constant that is always 6.67 x10^{-11} Nm^2/kg^2.

Example: Find the force of gravity between the Earth and Moon if their separation is 3.84 x 10^8 m and the mass of the Moon is 7.35 x 10^{22} kg and Earth's mass is 5.98 x10^{24} kg.

Using $F_g = (Gm_1m_2)/r^2$

$F_g = (6.67 \times 10^{-11})(7.35 \times 10^{22})(5.98 \times 10^{24})/(3.84 \times 10^8)^2$

$F_g = \sim 2 \times 10^{20}$ N

Example: Find the acceleration due to gravity (g) on the surface of Saturn on an object of mass m if Saturn has a mass of 5.67 x 10^{26} kg and a radius of 6.03 x 10^7 m.

Now we have two formulas for Fg. One for the surface of a planet and one that works anywhere, including the surface of the planet. If we are at the surface and we equate the two formulas we can solve for g.

Fg = Fg

$mg = GmM/r^2$ Here I am letting m be the mass of the object and M be the mass Saturn.

$\cancel{m}g = (6.67 \times 10^{-11})(\cancel{m})(5.67 \times 10^{26})/(6.03 \times 10^7)^2$ {since m is on both sides cancel it out}

g = 10.4 m/s^2 Therefore we would fall quicker to the surface of Saturn than Earth.

Rearranging we can also solve for an unknown mass or separation distance between two objects if we know the force of gravity between them.

Now you try pg 182 # 21, 22, 24, 25

2. Types of Energy and Work

After forces the next unit is work, energy and power.

Work is the process of energy transfer from one of its many forms to another.

Energy is the ability to do work.

Overall, the two definitions are used interchangeably. When we say work we mean energy, and vice versa.

There are many types of energy. **Read pg 216 of the textbook for a list and put definitions into your notes please.**

Work is calculated by the formula

$$\mathbf{W = F_{applied} \times \Delta d \cos\theta}$$

where W is work in joules (J), Fapplied is the applied force to an object in Newtons (N), θ is the angle between the applied force and displacement and Δd the change in position in meters (m).

Therefore a joule is a Newton x meters or J = Nm. Work is a scalar quantity, it has no direction. Only can be considered a positive work (working with the object) or negative work (working against the object).

There are three instances where is not done or where W = 0J. Yes it is possible to do something and still do no work!

1. No force is applied but the object is displaced (moves). Example: an object drifting in space. The object is moving through space but no force is being applied. Therefore Fapplied = 0 so W= 0 J

2. A force is applied but the object is not displaced. Example: you push on a wall but the wall does not shift in position. Therefore Δd = 0 so W = 0J (feels like you are doing work but not in a physics sense).

3. Force and displacement are at 90^o to one another. Example: Carrying a backpack to school. You apply a force upwards on the backpack to counteract gravity but you move forward as you walk. Hence the angle between the applied force and the change in position is 90^o and cos 90 = 0 so W = 0 J. Read pg 218 for more explanation on this.

Now you try pg 241 # 12, 13, 14, 15.

3. Power

Power is the rate at which work is done.

Mathematically, $P = \frac{W}{t}$

N.B. Power is also a scalar quantity.

Where W is the work done (J)
t is the time taken (s)
P is the power (W)

1 J/s = 1 Watt

A watt is a relatively small unit of power. Most of us are more familiar with horsepower as a unit of power. i.e. A 6.5 hp lawn mower.

1 horsepower = 745.7 Watts

Example: Find the power when a force of 300 N is applied to a a 10 kg cart for a distance of 25 m [E]. The angle between the force and the horizontal is 20°. The whole process takes 55 seconds.

First we need to find the work.

$W = Fd\cos\theta$

$W = 300(25)\cos 20$

W = 7048 J

Next find power.

P = W/t

P = 7048/55

P = 128 Watts

Example: What is this power in horsepower?

$P \div 745.7 = hp$

$128 \div 745.7 = 0.17$ hp

Now you try pg 242 # 23, 24, 25, 26

4. Kinetic and Gravitational Potential Energy

Now we are going to formalize two specific types of work (or energy) kinetic and gravitational as they are the ones we see and deal with the most often.

a. Kinetic Energy ~ is the energy that comes from movement. Any object or mass that moves has kinetic energy.

Kinetic energy is denoted by E_K and is still measured in J (joules).

The formula for kinetic energy is

$E_K = (mv^2)/2$	where m is mass in kg and v is velocity of the object in m/s.

Example: Find the kinetic energy of a racecar travelling at 20 m/s and having a mass of 1500 kg.

$E_K = (mv^2)/2$

$E_K = (1500 \times 20^2)/2$

$E_K = 300\ 000$ J or 300 kJ if we divide by 1000.

Example: If 2000 J is produced when a 10 g bullet is fired, what is the velocity of the bullet.

First get mass in kg m = 10 g x 1kg/1000 g = 0.01 kg

Next we need to rearrange our EK formula for velocity.

$$E_K = (mv^2)/2$$

$$2E_K = mv^2$$

$$2E_K/m = v^2$$

$$\boxed{v = \sqrt{(2E_K/m)}}$$

so $v = \sqrt{(2 \times 2000)/0.01}$

v = 632 m/s (one fast bullet).

Now you try pg 242 # 29, 30, 31

b. Gravitational Potential Energy ~ is the energy that comes from the position a mass or object is above a reference point.

Is a potential energy because the object doesn't have to fall but it could. If you are standing on the second floor of a house you have a higher potential energy than if you are standing on the first floor because you are higher off the ground. Doesn't mean you will fall, but the potential is there. When we drop something the potential energy is transformed into kinetic energy and the object picks up speed.

Gravitational potential energy is denoted by E_g and is measured in J (joules like all energy).

The formula for E_g is

$E_g = mgh$ where m is mass in kg, g is the acceleration due to gravity 9.8 m/s^2 and h is the height above the reference point (usually the floor) in m.

Example: Find the gravitational potential energy with reference to the ground of a 65 kg person standing on the edge of a 10 m cliff enjoying the view.

$E_g = mgh$

$E_g = (65)(9.8)(10)$

$E_g = 6370$ J

Now you try pg 243 # 37, 39, 40

Enjoy your week. Email if you have questions. Assignment coming Thursday.