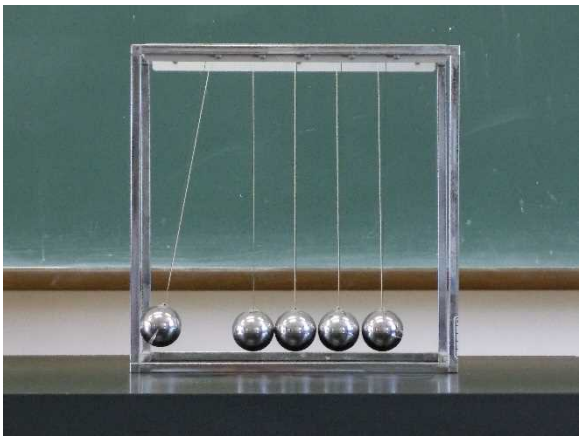
# 物理基礎　英語定義集

# Basic Japanese-English Physics Vocabulary with English Definitions



平成２６年７月

July 2014

**岡山県立倉敷天城高等学校**

Okayama Prefectural Kurashiki Amaki Senior High School

in collaboration with

協力校：岡山県立岡山一宮高等学校

Okayama Prefectural Okayama Ichinomiya
Senior High School

# 巻頭言

岡山県立倉敷天城高等学校
校　長　　中　塚　多　聞

このたび，岡山県立岡山一宮高等学校のご協力を得て本校で作成いたしました「物理基礎 英語定義集（Basic Japanese-English Physics Vocabulary with English Definitions)」の刊行に寄せまして，一言ご挨拶申し上げます。

グローバル社会の到来を迎え，これから社会に出て活躍する高校生にとって，その活躍の場が国内であれ国外であれ「英語が使えること」が必須の条件の一つになっています。このような状況を踏まえ，本校では，ＳＳＨ（スーパーサイエンスハイスクール）研究開発の一環として，平成２４年度に「英語が使える科学技術系人材の育成のための戦略構想」を策定し，実践を行っています。この構想の趣旨は，「間違えてもよいからどんどん英語を使っていこう」と呼び掛け，英語を使う抵抗感を小さくする試みで，本校が命名した科学英語読解メソッドＰａＲｅＳＫ（パレスク：Paragraph Reading for Science with Key Words）の理念の下，併設中学校及び高等学校の理科の授業などでの実践を積み重ねています。その研究成果物として，現在日本の高等学校で使われている「物理基礎」の教科書に記載されている用語を英語で解説したブックレットを刊行するはこびとなりました。ＳＳＨ校，ＳＧＨ（ス―パーグローバルハイスクール）校を始め，日本の多くの物理教室でご活用いただければ幸いです。また，用語には「ふりがな」を付してあり，日本の高等学校，大学へ留学されている留学生の皆様にもご活用いただける内容にしています。

なお，本校が策定いたしました前述の戦略構想及びＰａＲｅＳＫ，これまでの実践事例の詳細及びその効果につきましては，本校もしくはＪＳＴ（独立行政法人　科学技術振興機構）のＷｅｂページに掲載されております本校の「研究開発実施報告書」をご覧ください。また，このブックレットは本校のＷｅｂページにも掲載していますのでご活用ください。次の事業として，科学で使用する動詞（verbs）とその用例集を刊行する予定にしています。これからもこのブックレットをよりよいものにしてまいりたいと存じます。ご使用いただいた感想やご意見等をお寄せいただければ幸いです。

最後になりましたが，日ごろから本校のＳＳＨ研究開発事業をご支援いただいております，文部科学省科学技術・学術政策局，同省初等中等教育局，独立行政法人　科学技術振興機構，岡山県教育委員会の皆様に厚く御礼申し上げます。

【作成者より】

◯ラモン ファーガス（Ramon Fargas：岡山県立倉敷天城高等学校　講師）

日本の中学校・高等学校で科学英語の授業を始めて３年目になります。日本の中学生，高校生の科学英語の吸収力には目を見張るものがあります。このブックレットには，生徒の皆さんや科学を教える先生方のために，辞書を使うことなく，高校生で理解可能な英文を掲載しています。作成に当たっては，英語圏で使われている，できるだけ最新の教科書を参考にしました。

本書を手にした生徒の皆さんが将来英語を使って大きく羽ばたいていただくことを願っています。また，先生方には「力（Force)」の一語だけでもかまいません。日々の授業に少しずつでも英語を取り入れていただければ幸いです。

As the saying goes, you cannot fully understand one language unless you understand at least two.

◯仲達修一（Shuichi Nakadachi：岡山県立倉敷天城高等学校　指導教諭）

本校では，英語圏で使われている科学の教科書を補助教材として使いながら理科の授業を行う取り組みを行っています。カラフルな画像や写真のキャプションに記載されている英文のキーワードに着目してサイエンスの原理・法則を理解しようとする試みで，この取り組みをＰａＲｅＳＫ（パレスク）と命名しています。将来国際的に活躍できる科学者・技術者として必須の英語力として，専門用語に着目しながら大意を読み取り，必要な情報を取り出すことができる能力が挙げられます。専門用語（英語）の解説を日本語で行った後，バイリンガルで科学の原理・法則を学習するという流れで授業を構成しています。

このブックレットを作成する過程で，気がついたことがいくつかあります。そのうちの一つは，日本語の用語と英語の用語が必ずしも１対１に対応していないということです。例えば，Electric Field は「電場」もしくは「電界」と訳されていますが，なぜ２つの訳が出てきたのかについて，理学系の学者は「電場」と訳し，工学系の学者は「電界」と訳したということを以前理学系の人から聞いたことがあります。我が国の大学の起源について調べてみると，理学部は蕃書調所をその起源とし，工学部は明治期にあった工部省の工部大学校をその起源としているようです。一昨年，電気学会のある会合に出席させていただく機会を得て，このことを工部大学校の系統の方に尋ねてみたところ，そのとおりで間違いないであろうとのことでした。しかしながら核融合をやっている工学系の人は理学系の研究者が多いためか，「電場」「磁場」と言っていると教えてくださいました。現代の我々にとっては，「地球の磁界」「モーターの磁場」はやはり違和感が拭えません。「地球の磁場」「モーターの磁界」が感覚的にフィットします。逆に，「等加速度直線運動」などの英語による表現は複数存在することがわかりました。また，日本では，運動方程式は $ma=F$ と教えていますが，国際的には，$F=ma$ と教えているようです。このブックレットは，これらのことにも留意して作成しました。

このブックレットが英語を取り入れた物理の授業を実施する上で参考になれば幸いです。また，本書を手にした高校生たちが世界を舞台に臆することなく英語を使って活躍することを願ってやみません。

目次

# Basic Physics Vocabulary (物理基礎語彙)

## 物体の運動 (Motion of Objects)

1) 速さ (はやさ) = speed = the rate (比率) (割合) at which a moving object (物体) moves
SI (International System) unit of speed = (m/s)
(no direction (方向) (向き) only magnitude (大きさ))

2) 平均の速さ (へいきんのはやさ) = average speed = distance (距離) traveled divided by (割る) time of travel when speed is changing

3) 瞬間の速さ (しゅんかんのはやさ) = instantaneous speed = speed at a specific instant of time (特定の瞬間) or point along a path (経路に沿った) (e.g., value that can be read on the car speedometer)

4) 等速直線運動 (とうそくちょくせんうんどう) = uniform linear motion = straight-line motion with constant velocity = motion at a constant speed (等速) and in a straight line

5) 速度 (そくど) = velocity = speed with direction that an object (物体) has

6) ベクトル= vector = a physical quantity (物理量) that has both magnitude (大きさ) and direction (向き)

7) スカラー = scalar = a physical quantity (物理量) that has magnitude (大きさ) but no direction

8) 等速運動 (とうそくうんどう) = uniform motion= a motion with a constant speed (等速) (including non-linear motion)

9) 変位 (へんい) = displacement = the change in position (位置) of an object (物体)

10) 平均の速度（へいきんのそくど）= average (mean) velocity = total displacement (変位) divided by the time interval (間隔) ($\Delta x / \Delta t$)

11) 瞬間の速度（しゅんかんのそくど） = instantaneous velocity = velocity at any instant of time or point along a path (経路に沿って)

12) 合成速度（ごうせいそくど）= resultant (composite) velocity = sum of two or more velocities (e.g., A boat on a calm lake is moving east at 10 km/h and a passenger (乗客) is running west at 12 km/h on the boat's deck. The resultant velocity of the passenger as seen by a fixed observer (静止している観測者) on the side of the calm lake (穏やかな湖) is 2 km/h going west.)

13) 相対速度（そうたいそくど）= relative velocity = velocity of an object seen by a moving observer (e.g., Suppose a passenger on a bus going north with a speed of 60 km/h is watching a motorcycle on the next lane (車線) going north with a speed of 50 km/h, the relative velocity of the motorcycle is 10km/h going south as seen by this moving passenger (乗客).)

14) 加速度（かそくど）= acceleration = the rate (割合) of change of velocity (速度) of a moving body (object) expressed in meters per second squared ($m/s^2$)

15) 平均の加速度（へいきんのかそくど）= average (mean) acceleration = total change in an object's velocity divided（割る）by the time interval (間隔)

16) 瞬間の加速度（しゅんかんのかそくど）= instantaneous acceleration = the rate (割合・率) at which an object's velocity is changing at any instant and at any point along a path (経路に沿って)

17) 等加速度直線運動（とうかそくどちょくせんうんどう）linear motion with constant acceleration = straight-line motion with uniform acceleration = an object's motion with constant acceleration (等加速度) in a straight line

18) 初速度（しょそくど）= initial velocity = velocity at which an object starts at the beginning of a time interval (間隔)

19) 自由落下（じゆうらっか）= free fall = falling motion (落下運動) only under the influence of gravity (重力の影響を受けて) without air resistance (空気抵抗) or initial speed (初速)

20) 重力加速度（じゅうりょくかそくど）= gravitational acceleration = downward acceleration of a free-falling object caused by gravity

21) 放物運動（ほうぶつうんどう）= projectile (parabolic) motion = motion of an object along a curved path (曲線軌道) only under the influence of gravity (重力の影響を受けて) with an initial velocity (初速度)

22) 放物線（ほうぶつせん）= parabola = the curved path (曲線軌道) followed by a projectile (飛翔体) under the influence (影響) of constant gravity only

23) 等加速度運動（とうかそくどうんどう）= motion with constant acceleration = uniformly accelerated motion

## 力のはたらきとつりあい (Properties and Equilibrium of Forces)

24) 力（ちから）= force = a push or pull on an object, or an interaction (相互作用) between 2 objects or between an object and its environment (環境). It has magnitude and direction.

25) 作用点（さようてん）= point of action = point of force acting on (働く) a body or object

26) 作用線（さようせん）= line of action = an imaginary (invisible) line (仮想の線) that includes force

27) 重力（じゅうりょく）= gravity = force of attraction (引力) that exists (存在する) between the earth and all objects

28) 質量（しつりょう）= mass = a measure (測定値) of the amount (量) of matter (物質) in an object

29) 重さ（おもさ）= weight = the force of gravity (重力) acting on (働く) a body (物体) or substance (物質)

30) 垂直抗力（すいちょくこうりょく）= normal force (normal reaction) = a perpendicular (垂直) reaction force (反作用の力) exerted on (およぼす) an object at rest or in motion on a surface (equal to the object's weight if on a horizontal surface (水平面))

31) 摩擦力（まさつりょく）= friction (frictional) force = the force that opposes (妨げる) the motion of objects as they move past (通過する) each other

32) 静止摩擦力（せいしまさつりょく）= static friction (frictional) force = force that resists (妨げる) the start of sliding motion (滑り運動) between 2 surfaces (表面) that are in contact and at rest (e.g., a block of wood (木片) resting on an inclined plane (傾斜面))

33) 動摩擦力（どうまさつりょく）= kinetic friction (frictional) force ＝ force that opposes (妨げる) the movement of 2 surfaces that are in contact and are sliding over each other (e.g., block of wood sliding down on an inclined plane)

34) 張力（ちょうりょく）= tension (tensile force of string) = the pulling force exerted by (およぼされた) a stretched (延ばした) string or rope to an attached object

35) 弾性（だんせい）= elasticity = the property (性質) of a material to return to its original shape and length (長さ) after being compressed (縮んだ) or stretched (伸びた)

36) 弾性力（だんせいりょく）= elastic force = force exerted by a material when it is stretched (伸びた) or compressed (縮んだ)

37) フックの法則（フックのほうそく）= Hooke's Law = The amount of stretch (伸び) or compression (縮み) of an elastic material (弾性材料) is directly proportional (比例して) to the applied force (加えた力).

38) ばね定数（ばねていすう）= spring constant = constant $k$ measured in newtons per meter in the formula of Hooke's Law ($F = kx$) that tells how stiff (硬い) a spring is

39) 遠隔力（えんかくりょく）= action at a distance = force acted on (およぼされた) an object without touching it

40) 万有引力（ばんゆういんりょく）= universal gravitation = gravitational force between objects depending on their mass (質量) and distance (距離)

41) 静電気力（せいでんきりょく）= electrostatic force = the force between electrically charged (電荷を持つ) objects

42) 磁気力（じきりょく）= magnetic force = the attraction (引力) and repulsion (斥力) between magnetic poles (磁極)

43) 力の合成（ちからのごうせい）= composition (summation (合計・総和)) of forces = the combination of 2 or more forces into a single equivalent (同等の) force (sum of forces)

44) 合力（ごうりょく）= resultant force (sum of forces) = the sum of all forces acting on (働く) an object

45) 力の分解（ちからのぶんかい）= decomposition (resolution) of force = separation (分解) of resultant force (合力) into components (成分)

46) 分力（ぶんりょく）= component of force = a component (成分) of resultant force

47) 力の成分（ちからのせいぶん）= components of force = each component of resultant force

($x$成分 = $x$-component, $y$成分 = $y$-component)

48) 力のつりあい（ちからのつりあい）= equilibrium of forces = balanced forces that act on (働く) an object (upward force balanced by downward force and rightward force balanced by leftward force acting on an object). The net force on an object is zero.

49) つりあいの状態（つりあいのじょうたい）= equilibrium state (balanced state) = summation (合計・総和) of all forces is equal to zero

50) 作用（さよう）= action = force exerted by (およぼす) an object on another object

51) 反作用（はんさよう）= reaction = force which has the same magnitude (大きさ) and opposite direction (逆向き)

52) 作用･反作用の法則（さようはんさようのほうそく）= law of action and reaction = If object A exerts (およぼす) a force on object B, then object B exerts an equal and opposite force back on object A.

53) 圧力（あつりょく）= pressure = the force acting (およぼす) on a unit area ($1m^2$) (force divided by area)

54) 流体（りゅうたい）= fluid = a non-solid state (状態) of matter (物質) which includes liquids (液体 e.g., water) and gases (気体 e.g., air)

55) 大気圧（たいきあつ）= atmospheric pressure = the pressure exerted (およぼされる) by the weight (重さ) of the atmosphere (大気) at a given altitude (高度)

56) 水圧（すいあつ）= hydraulic pressure = pressure exerted (およぼされる) on an object in a liquid (液体) depending on (依存する) depth (深さ), atmospheric pressure (大気圧) and liquid density(液体の密度)

57) 浮力（ふりょく）= buoyancy (buoyant force) = upward force exerted (およぼす) by a fluid (流体) on an object partly or completely immersed (沈められた) in it

58) アルキメデスの原理（アルキメデスのげんり）= Archimedes' principle = The buoyant force (浮力) acting on an object in a fluid (流体) is equal to the weight (重さ) of the fluid displaced (押しのけられた) by the object.

59) 体積（たいせき）= volume = the amount of space occupied (占められている) by an object

## 運動の法則 (Laws of Motion)

60) 慣性の法則（かんせいのほうそく）= law of inertia (運動の第 1 法則 = first law of motion) = When there are no forces or when forces are in equilibrium (つり合っている), a body at rest remains at rest and a body already in motion remains in motion in a straight line with a constant velocity (等速) (constant speed and direction).

61) 慣性（かんせい）= inertia = the tendency (傾向) of an object at rest to remain at rest, and the tendency of an object to keep moving if it is in motion（動いている）

62) 運動の法則（うんどうのほうそく）= law of motion (運動の第 2 法則 = second law of motion) = The net force on a body (object) is equal to the product of the body's mass and its acceleration ($F = ma$). The direction of the acceleration is in the direction of the applied net force (加わっている合力). The acceleration (加速度) of a body is directly proportional (比例) to the net force acting on it and inversely proportional (反比例) to the mass of the body ($a = F/m$).

Note: In Japan, ($ma = F$) is commonly used.

63) 運動の第 3 法則（うんどうのだいさんほうそく）= third law of motion (ニュートンの運動の法則) = Newton's law of motion) = For every action, there is an equal and opposite reaction (equal magnitude (同じ大きさ) and opposite direction (逆方向)).

64) 運動方程式（うんどうほうていしき）= equation of motion = $F$ (force in newtons (N)) = $m$ (mass in kilogram (kg)) × $a$ (acceleration in meters per second squared ($m/s^2$)) ($F = ma$)

Note: In Japan, $ma = F$ is commonly used.

65) ニュートン力学（ニュートンりきがく）= Newtonian mechanics = the study of the causal relationship (因果関係) between force, mass, and motion in the natural world

66) 最大摩擦力（さいだいまさつりょく）= maximum frictional force = the maximum value of the static frictional force just before an object starts to move or slide on a solid surface
$F_0 = \mu N$ ($F_0$: maximum frictional force, $\mu$ (ミュー): coefficient of static friction, $N$: normal force)

67) 静止摩擦係数（せいしまさつけいすう）= coefficient of static friction (scalar value depending on material and surface of 2 objects in contact) = the ratio (比率) between the maximum force of friction (newtons) felt by two solid surfaces in contact while at rest and the normal force (kg)×(9.81m/s²), $\mu$ : coefficient $F_0=\mu N$

68) 摩擦角（まさつかく）= friction angle = the maximum angle that an object can be at rest just before it slides (滑る) on an inclined plane (斜面)

69) 動摩擦係数（どうまさつけいすう）= coefficient of kinetic friction (scalar value depending on material and surface of 2 objects in contact) = the ratio of the kinetic friction force to the normal force (垂直抗力). The more slippery (滑り易い) the surface, the smaller the coefficient. $\mu'$: (ミュープライム) coefficient $F'=\mu' N$

70) 空気抵抗（くうきていこう）= air resistance (air drag) = resisting force (抵抗力) produced (生じる) as an object moves through air

71) 終端速度（しゅうたんそくど）= terminal velocity = the constant speed an object reaches when falling through resisting medium (抵抗を与えている媒体). In this case, the force of air resistance (空気抵抗) equals the force of gravity (重力).

## 仕事と力学的エネルギー (Work and Mechanical Energy)

72) 仕事（しごと）= work = ($W = Fs$) Work is done only when components（成分）of a force are parallel（並行に）to the displacement (1N・m = 1J) ($W=Fs\cos\theta$). The component of a force perpendicular (垂直に) to the displacement (変位) does no work ($\theta=90^\circ$) ($\cos 90^\circ=0$).

73) 仕事の原理（しごとのげんり）= principle of work = If friction and the mass of a tool (道具) that can be used for work are ignored (無視する), the amount of work would not change whether the tool is used or not (e.g., lifting an object vertically (垂直に) by hand to a certain height (ある高さ) or moving an object at a greater distance to the same height on an inclined plane (斜面) to do the same amount of work).

74) 仕事率（しごとりつ）= power = rate at which work is done or energy divided by (割る) time (1watt = 1Joule/second)
$P = W/t = F \cdot s/t = F \cdot v$

75) 馬力（ばりき）= horsepower (hp) = a unit of power equal to 746 watts for mechanical horsepower (英馬力：ヤード・ポンド法) and 736 watts for metric horsepower (仏馬力：メートル法)
(Possible origin: word used by James Watt (1736-1819) referring to (に関して) a brewery（ビールの醸造所・ブルワリー) horse's power while walking in circles (attached to a mill that ground (挽く) mash (すりつぶした麦芽を湯に浸したもの) for making beer) with a 7.3-meter diameter（直径）and pulling an 82 kg-weight at a speed of 55 meters per minute)
(82kg×55 meters = 4510 kg-force meter per minute ÷ 60 seconds = 75kg-force meter per second×9.81 joules per second = 736 watts)

76) エネルギー = energy = an object's ability (能力) to do work

77) 運動エネルギー（うんどうエネルギー）= kinetic energy = energy that an object has when it is moving ($K = \frac{1}{2}mv^2$)

78) 重力による位置エネルギー（じゅうりょくによるいちエネルギー）= gravitational potential energy = the energy depending upon (に依存する) an object's mass (質量) and height (高さ) above a reference point (基準点)
(mass × gravitational acceleration × height：$U = mgh$)

79) 弾性エネルギー（だんせいエネルギー）= elastic potential energy = energy stored (をもつ) in a spring (ばね) or elastic body (弾性体) when it is stretched or compressed ($U = \frac{1}{2}kx^2$)

80) 保存力（ほぞんりょく）= conservative force = force in which the work done on an object between two points depends only on the starting and ending points. It does not depend on the path (経路によらない). (e.g., conservative force of gravity: When going up a mountain using a shortcut or a longer route, the work done by the force of gravity is the same. ; non-conservative force of friction: the total work done by the friction force when sliding an object on a rough surface (荒い表面) depends on the length of the path )

81) 位置エネルギー (いちエネルギー) = potential energy = energy stored due to an object's position rather than its motion

82) 力学的エネルギー（りきがくてきエネルギー）= mechanical energy (total) = the sum (総和) of kinetic energy and potential energy that an object has ($mgh + \frac{1}{2}mv^2$)

83) 力学的エネルギー保存の法則（りきがくてきエネルギーほぞんのほうそく）= law of conservation of mechanical energy = With only conservative forces causing energy changes in an object, the potential energy may increase and the kinetic energy may decrease (or vice-versa = 逆もまた同様), but their sum (総和), the object's mechanical energy, remains constant (一定に保たれる).

## 熱とエネルギー (Heat and Energy)

84) 熱運動（ねつうんどう）= thermal motion = random (乱雑な・ランダム) motions of molecules, atoms, electrons or other subatomic particles (素粒子) in an object

85) ブラウン運動（ブラウンうんどう）= Brownian motion (movement) = the disorderly movement (不規則な運動) of colloidal particles (コロイド粒子・微粒子) in a fluid (流体) due to collisions (衝突) with the molecules (分子)

86) セルシウス温度（セルシウスおんど）= degree Celsius = the temperature scale that fixes the freezing point of water at 0 degrees and the boiling point of water at 100 degrees (with pressure of $1.013 \times 10^5$Pa or 1 atmospheric pressure exerted on (the earth's surface at sea level).

87) 絶対零度（ぜったいれいど）= absolute zero = the temperature at which thermal motion energy is at zero (0 K on the Kelvin scale or -273.15°C on the Celsius scale).

88) 絶対温度（ぜったいおんど）= absolute temperature = the temperature of an object on a Kelvin scale where 0 is taken as absolute zero = T[K] = t(°C)+273

89) 熱平衡（ねつへいこう）= thermal equilibrium = the state (状態) in which 2 bodies in physical contact (物理的に接触する) with each other have the same temperature

90) 熱（ねつ）= heat = the thermal energy transferred from objects with higher temperature to objects with lower temperature. Heat flow (transfer) is caused by collisions (衝突) of molecules (分子) and atoms in objects.

91) 熱量（ねつりょう）= quantity of heat = the amount of thermal energy transferred from objects with higher temperature to objects with lower temperature. The SI unit of heat quantity is Joule.

92) 物質の三態（ぶっしつのさんたい）= three states of matter = solid, liquid, and gas

93) 融解熱（ゆうかいねつ）= heat of melting (heat of fusion) = the heat energy absorbed (吸収する) by a substance when it transforms from solid to liquid

94) 蒸発熱（じょうはつねつ）= heat of evaporation (vaporization) = the amount of heat a liquid (液体) must absorb (吸収する) for 1 kg of it (J/kg) to be converted (状態変化) from the liquid to the gaseous state (in Japanese high school textbooks, J/g is used.)

95) 潜熱（せんねつ）= latent heat = the energy per unit mass that is transferred during a phase change (相変化) of a substance (J/g) without change of temperature

96) 熱容量（ねつようりょう）= heat capacity = amount of heat needed to raise the temperature of a specified amount (一定量) of a substance (物質) by 1°C (one degree Celsius) or 1 K (one Kelvin)

97) 比熱（ひねつ）= specific heat = the amount of heat needed to raise the temperature of 1kg of a substance by 1°C

98) 熱量の保存（ねつりょうのほぞん）= conservation of heat = The amount of heat lost（失った）by the substance with a higher temperature is equal to the amount of heat gained (得た) by the substance with a lower temperature.

99) 熱膨張（ねつぼうちょう）= thermal expansion = expansion of material length or volume due to its temperature increase as the kinetic energy of the particles of the material (物質を構成している粒子) increases

100) 線膨張（せんぼうちょう = linear expansion = rate of change in length (長さ) of a solid material (固体) depending on temperature change

101) 線膨張率（せんぼうちょうりつ）= coefficient of linear expansion = the constant（定数）which describes the thermal expansion properties (特性) of a particular material $l = l_0 (1 + \alpha t)$

102) 体膨張（たいぼうちょう）= volume (cubical) expansion = increases in volume for both solid and liquid materials due to temperature increase

103) 体膨張率（たいぼうちょうりつ）= coefficient of volume (cubical) expansion = the constant（定数）which describes（説明する）the volume expansion properties (特性) of a particular material
$V = V_0 (1 + \beta t)$

104) 内部エネルギー（ないぶエネルギー）= internal energy = the sum of all the kinetic and potential energies of all the atoms and molecules (分子) in a substance

105) 熱力学の第１法則（ねつりきがくのだいいちほうそく）= first law of thermodynamics = the change in internal energy of a substance equals the work done on it plus the heat transferred to it. ($\Delta U = Q + W$)
(e.g., When using the air pump to put air in a bicycle tire, the temperature of the air increases (上昇する).

106) エネルギー保存の法則（エネルギーほぞんのほうそく）= energy conservation law = When a type (種類) of energy decreases (減少する), the same amount of a different type of energy forms (発生する). The sum of energy before and after the change (変化) is the same (is conserved).

107) 熱機関（ねつきかん）= heat engine = a device (装置) that extracts (取り出す) (takes out) heat and transforms (変換する) it into mechanical energy (力学的エネルギー) or mechanical work. It absorbs (吸収する) heat from a hot reservoir (熱だめ) (high-temperature source) (e.g., burning fuel (燃料)), transforms some of this energy into usable mechanical energy or work, and outputs the remaining energy as heat to some cold reservoir (e.g., radiator or exhaust pipe (排気管)).

108) 熱効率（ねつこうりつ）= thermal efficiency = the ratio of usable heat energy output (work done out) to heat energy input ($e = W/Q_c$) ($W = Q_h - Q_c$) (how effectively an engine converts (変換する) a fuel's heat energy into usable work)

109) 可逆変化（かぎゃくへんか）= reversible process (change) = in an ideal state (理想的な状況), a process that can be reversed (e.g., pendulum motion if friction, air resistance, etc. can be ignored (無視できる))

110) 不可逆変化（ふかぎゃく変化）= irreversible process (change) = a one-way thermodynamic (熱力学的) process that proceeds or goes naturally in one direction but not the opposite (e.g., heat flowing naturally from a hot object to a cold one, but not the reverse)

111) 気体の圧力（きたいのあつりょく）= gas pressure = The cause of pressure is due to forces exerted by (およぼす) gas molecules (分子) during collisions (衝突) on the walls of the container (容器の壁に力をおよぼす). ($p = F/S$)

## 波の性質（Nature of Waves)

112) 波動（はどう）= wave motion = a series (一連) of periodic (周期的) oscillations (振動) of the particles (粒子) of a substance (物質) or medium (媒質 e.g., water) set in motion (動かされる) by energy. The medium does not travel through space. Its individual (個々の) particles move back and forth or up and down around their equilibrium positions (つり合いの位置). Waves transport energy but not matter from one place to another.

113) 波源(はげん) = wave source = the place or point where the oscillation (振動) first started

114) 波形(はけい) = wave form = the complete shape of the wave

115) 波の速さ(なみのはやさ)＝wave speed = one wavelength (λ: lambda) times the number of cycles per second (*f*) depending on the nature of the medium (媒質)
Frequency × Wavelength （$v=\lambda/T$　$v=f\lambda$　$f=1/T$）
$v$ [m/s]=speed　$f$ [Hz]=frequency　λ[m]=wavelength　$T$ [s]=period

116) 単振動（たんしんどう）= simple harmonic motion = a periodic motion (周期運動) of the medium (媒質) that repeats itself at regular intervals (周期) over the same path (経路) as a result of a restoring force (復元力) that is proportional (比例) to displacement (変位)

117) 等速円運動（とうそくえんうんどう）= uniform circular motion = motion that is referred to (言及する) when the speed of an object in circular motion is constant (一定) (e.g., Ferris wheel (観覧車) moving at a constant speed)

118) 周期（しゅうき）= period = time required (要する時間) for one complete cycle of oscillation (振動) of the medium's particles (媒質の粒子)

119) 振動数（しんどうすう）= frequency = the number of cycles or oscillations (振動) per unit of time (1 second), or the number of waves produced per unit of time (Hz=hertz is the SI unit of frequency $f=1/T$)

120) 振幅（しんぷく）= amplitude = maximum displacement (変位) from the equilibrium position (つり合いの位置) (distance from the equilibrium position to a crest or trough)

121) 山（やま）= crest (peak) = the highest point above the equilibrium position of a wave

122) 谷（たに）= trough (valley) = the lowest point below the equilibrium position of a wave

123) 正弦曲線（せいげんきょくせん）= sine curve = a curve whose shape represents（表す）the crests and troughs of a wave with constant amplitude

124) 正弦波（せいげんは）= sine (sinusoidal) wave = a wave produced by a source (源) that oscillates (振動する) with simple harmonic motion (単振動)

125) 波長（はちょう）= wavelength = distance or length of one complete wave cycle (from crest to crest or trough to trough)

126) 位相（いそう）= phase = a specific point or location (of an oscillation) within a cycle of a wave measured as an angle (角度) in degrees (radians)

127) 同位相（どういそう）= synphase (in phase) = particles on a wave which are one or more wavelengths apart whose motion or displacement (変位) from their equilibrium positions (つり合いの位置)are the same

128) 逆位相（ぎゃくいそう）= antiphase (out of phase) = particles on a wave which are half a wavelength apart whose motion or displacement from their equilibrium positions are exactly the opposite

129) 横波（よこなみ）= transverse wave = a wave where the particles of the medium vibrate（振動する）perpendicular to（垂直に）the direction the wave is moving (e.g., moving up and down with the hand one end of a horizontally stretched "slinky" (スプリングのおもちゃ) with the other end fixed)

130) 縦波（たてなみ）= longitudinal wave = a wave where the particles of the medium oscillate parallel (平行に) to the direction the wave is moving (e.g., sound waves or alternately (交互に) compressing and stretching a "slinky" or spring)

131) 疎密波（そみつは）= compression wave = longitudinal waves that produce compression（密）and rarefaction（疎）when traveling through a medium (媒質)

132) 波のエネルギー（なみのエネルギー）= energy of wave = the energy transported by a wave from one place to another which is transferred as vibrational energy from particle to particle of the medium (媒質)

133) 表面波（ひょうめんは）= surface wave = a wave in which particles (分子) of the medium (媒質)undergo a circular motion (円運動)

134) 重ねあわせの原理（かさねあわせの原理）= principle of superposition = When two or more waves interfere (干渉する), the resulting displacement of the medium at any location is the algebraic sum of the displacements of the individual waves at that same location.

135) 合成波（ごうせいは）= resultant wave = a wave composed of many simple sinusoidal waves of different amplitudes, wavelengths, and frequencies

136) 波の独立性（なみのどくりつせい）= independency of waves = the nature (性質) of waves to not affect (影響をおよぼさない) each other or change their paths after meeting along a medium (媒質)

137) 定常波（ていじょうは）（定在波（ていざいは））= standing (stationary) wave = a wave pattern that forms when two waves of the same frequency (周波数), wavelength (波長), and amplitude (振幅) travel in opposite directions (反対方向) and interfere (干渉する)

138) 進行波（しんこうは）= progressive (traveling) wave = a wave that transports energy as it travels from one location to another in an unconfined (自由な) space along a medium

139) 節（ふし）= node = the point in a standing wave that remains still (静止状態) at all times (zero displacement or amplitude)

140) 腹（はら）= antinode (loop) = a point in a standing wave (midpoint between 2 nodes) where the largest displacement (変位) takes place

141) 入射波（にゅうしゃは）= incident wave = an incoming wave that strikes a fixed or free end (boundary = 境界)

142) 反射波（はんしゃは）= reflected wave = a wave that turns back after it strikes a fixed or free end (boundary)

143) 自由端反射（じゆうたんはんしゃ）= reflection at free end = After an incident wave (入射波) reaches (達する) the medium's free or loose end (or non-rigid (非剛体) boundary), a non-inverted reflected wave returns.

144) 固定端反射（こていたんはんしゃ）= reflection at fixed end = After the incident wave (入射波) reaches (達する) the medium's fixed end (or rigid (剛体) boundary), an inverted reflected wave returns.

## 音波 (Sound Waves)

145) 音波（おんぱ）= sound waves = longitudinal waves (縦波) with regions of compression (密) and rarefaction (疎) resulting (の結果として) from the back and forth vibration (振動) of the particles (物質の粒子) of a medium (媒質)

146) 音の 3 要素（おとの３ようそ）= three factors (要因) of sound = pitch (音の高さ), loudness (音の大きさ), and timbre (音色(ねいろ))

147) 音の高さ（おとのたかさ）= pitch = a measure of how high (e.g., soprano voice) or low (e.g., bass voice) a sound is depending on (による) the frequency (振動数) of the sound wave (the higher the pitch, the higher the frequency)

148) 超音波(ちょうおんぱ) = ultrasonic waves = sound waves with frequencies (振動数) above 20,000 Hz

超低周波(ちょうていしゅうは) = infrasonic waves = sound waves with frequencies less than 20 Hz

149) 音の大きさ（おとのおおきさ）＝loudness = related to the amplitude (振幅)of a sound wave and the power of hearing (聴力)of a person. The bigger the amplitude, the louder the sound.

150) 音色（ねいろ）= timbre = the quality of sound or tone color (音色) resulting from the combination of harmonics (倍音) (e.g., different sounds of the same note (音符) played on a guitar and played on a flute having the same pitch (音の高さ) and loudness (音の大きさ))

151) うなり= beat = the periodic variation (周期的な変化) in the amplitude (振幅) of a wave that is the superposition (重ね合わせ) of two waves of slightly different frequencies that makes a listener hear an alternation (交互) of loud and soft sounds

152) うなりの周期（うなりのしゅうき）= period of beat = the time interval (間隔) between two successive (次に続く) beats (i.e. two successive loud sounds)

153) 固有振動数（こゆうしんどうすう）= natural (eigen) frequency = the frequency or frequencies at which an object tends to vibrate (振動しやすい) with when struck (打たれる・ぶつかる)

154) 基本振動 (きほんしんどう) = fundamental (vibration) frequency = the lowest frequency of vibration of a standing wave (定常波)
(first harmonic corresponding to one antinode (腹) or loop)

155) 基本音（きほんおん）= fundamental tone = the first harmonic (from the 2nd harmonic = overtones (倍音))

156) 線密度(せんみつど)= linear density = the mass or weight per unit length (for strings, ropes, or cables) (kg/m)

157) 気柱（きちゅう）= air column = the body of air inside the tube or pipe of a wind instrument (管楽器)

158) 閉管（へいかん）= closed tube (closed-ended pipe) = a tube or pipe of a wind instrument (管楽器) that has one end closed off, and the other end open to the air

159) 開管（かいかん）= open tube (open-ended pipe) = a tube or pipe of a wind instrument (管楽器) that has both ends open to the air

160) 共振（きょうしん）（共鳴（きょうめい））= resonance = a phenomenon (現象) that occurs (起こる) when a second object (物体) vibrates at its natural frequency (固有振動数) due to the vibration (振幅) of a first object. The resulting vibration of the second object has a larger amplitude (振幅).

161) 開口端補正（かいこうたんほせい）= open end correction = measurable length that must be added on to the tube because the position of the antinodes (腹) extend (延長する) beyond the tube's open end

## 静電気と電流 (Static Electricity and Electric Current)

162) 帯電（たいでん）= electrification（摩擦電気 = triboelectric charging) = a phenomenon (現象) in which certain materials become electrically charged (電気を帯びる) after they come into contact (触れあう) with another different material through friction (摩擦). The two charges (電荷) are positive (正) and negative (負).

163) 静電気（せいでんき）= static electricity = when things are rubbed (こする) together, electrons can move from one object to another object made of different material. If the object gets extra electrons, it becomes negatively charged. The other object that lost the electrons becomes positively charged. When charges are separated (分けられる) like this, static electricity is generated (生じる).

164) 静電気力（せいでんきりょく）= electrostatic force = the force of attraction (引力) or repulsion (斥力) between electric charges (電荷)

165) 電荷(でんか) = electric charge = the physical property (物理的特性) of substances that can be electrically charged (two types of electric charges: positive and negative due to (原因で) an imbalance (ふつりあい) in the number of protons and electrons)

166) 電気量（でんきりょう）= quantity of electricity = the quantity of electric charge (SI unit: coulomb クーロン)
(1 coulomb = an object would need an excess (超過) or shortage (不足) of $6.25 \times 10^{18}$ electrons to have a total charge of -1 C or +1 C)

167) 原子核（げんしかく）= atomic nucleus = the central part of the atom consisting (構成されている) of positively charged (正電荷をもつ) protons（陽子）and neutrally charged（電荷をもたない）neutrons (中性子), surrounded (とりまく) by electrons (電子) which have a negative charge (負電荷)

168) 電気素量（でんきそりょう）= elementary electric charge (e) = a measured electric charge quantity expressed in coulomb (C) that a single proton ($+1.6 \times 10^{-19}$ C) and electron ($-1.6 \times 10^{-19}$ C) have.

169) 電圧（でんあつ）（電位差（でんいさ））= voltage (potential difference) = the electromotive force (起電力) or pressure (measured in volts) usually supplied (供給する) by either a generator or battery. It drives electrons around a circuit (回路) causing current (電流) to flow. It is a measure of potential difference (電位差) between two points (i.e., difference in potential energy per charge between points A and B)
1 volt = 1Joule of energy per coulomb = energy/charge
Energy transferred (J) = voltage (V) × charge (C)

170) 電流（でんりゅう）= electric current = the rate (割合) at which charges pass through a given area, like a cross-section (断面) of a wire, per unit of time (SI unit for current: ampere (A(アンペア)))
(1 ampere = 1 coulomb / second) (coulomb = ampere × second)

171) 直流電流（ちょくりゅうでんりゅう)= direct current (DC) = an electric current where the flow of charge is in one direction only (e.g., current directed from the positive terminal to the negative terminal of a battery)

172) オームの法則 （オームのほうそく） = Ohm's Law = When resistance is constant, the current is proportional to the potential difference. The current in a conductor (導体) is equal to the voltage applied (加える) to it divided (割る) by its resistance.
$I = V/R$ or $V = IR$ or $R = V/I$
(relationship between current, voltage, and resistance)

173) 電気抵抗 (でんきていこう) = electric resistance (resistance = $R$) = a measure of the opposition (流れの反対) to current flow by a material or device (装置)
(SI unit: Ω(ohm))

174) 抵抗率 （ていこうりつ) = resistivity ( ρ (rho)) = the quantity that measures how well a substance (物質) resists (抵抗する) carrying a current (unit = ohm·meter (Ω·m)) $R = \rho \cdot l/A$ ($A$ = cross-sectional area (断面積))

175) 導体 (どうたい) = conductor = a substance or material that allows electrons to flow freely (自由に流れる) through it (e.g., silver, copper, and iron)

176) 不導体 (ふどうたい) 絶縁体 (ぜつえんたい) = insulator = a substance or material whose electrons are not easily freed because they are tightly bound (しっかりと結合している) to their nuclei. It has a very high resistance to the flow of electrical current across the body of the material (e.g., rubber, glass, and wood).

177) 半導体 (はんどうたい) = semiconductor = a substance or material that has electrical resistivity (抵抗率) midway (中間) between those of conductors and insulators (e.g., silicon (ケイ素) and germanium (ゲルマニウム))

178) 大規模集積回路（だいきぼしゅうせきかいろ）= large-scale integrated circuit (LSI) = whole electrical circuits etched into (刻み込む) a piece of semiconducting material just a few millimeters square

179) 発光ダイオード（はっこうダイオード）= light-emitting diode (LED) = a semiconductor device that glows when electricity is passed through it. It converts (変換する) electrical energy into light or infrared radiation (赤外放射).

180) 直列接続（ちょくれつせつぞく）= series connection
直列回路（ちょくれつかいろ）= series circuit = an electrical circuit where the current from the source has only one path and flows through each resistor (e.g., light bulbs 電球). As more resistors (抵抗器) are added, the total current within the circuit decreases.

181) 並列接続（へいれつせつぞく）= parallel connection
並列回路（へいれつかいろ）= parallel circuit = an electrical circuit where the current from the source splits into more than one path. The current flows into separate resistors that receive the same voltage. The sum of currents in parallel resistors equals the total current.

182) 電流計（でんりゅうけい）= ammeter = a device or instrument used to measure electric current. It has a very low internal resistance so as not to change the current to be measured.

183) 内部抵抗（ないぶていこう）= internal resistance = the resistance within an ammeter, voltmeter, or battery. When there is a current, the resistance of the source causes a drop in the source voltage (電源電圧).

184) 電圧計（でんあつけい）= voltmeter = a device or instrument used to measure potential difference (電位差). It has a very high internal resistance so as not to draw (引き込む) a large current from the circuit.

185) 電源（でんげん）= power supply = a device (装置) that supplies (供給する) electrical energy to a circuit (回路) or load (負荷) (e.g., motor or light bulb)

186) ジュール熱 （ジュールねつ）= Joule heat = heat produced by an electric current if the current is expressed in amperes, the resistance in ohms, and the time in seconds. The heat produced is equal to the product of the resistance of the conductor, the square of the current, and the time for which it flows ($RI^2t$).

187) 起電力（きでんりょく）= electromotive force (emf) = not a force or power but an energy-per-unit-charge (1Coulomb) quantity supplied by a source of electric power (e.g., battery or generator) making current flow from a lower to a higher potential around an electrical circuit. The SI unit of emf is the volt (1V=1J/C).

188) 電力 = electric power = electric energy used per second: the rate at which an electrical machine uses energy or converts it into other forms of energy (e.g., light, heat) usually measured in watts (1watt = 1Joule/second). It is equal to the product of the voltage and the current flowing (e.g., an electric lamp passing a current of 0.6 amps at 100 volts using 60 watts of electric power) (formula: $P = IV = RI^2 = V^2/R$).

189) 電力量（でんりょくりょう）= electric energy = total work done or energy supplied by the source of emf (起電力) (e.g., battery emf in volts) in maintaining the current in an electric circuit for a given time：

Electric energy = electric power × time = $Pt$

Formula for Electric energy: $Pt = IVt = RI^2t = V^2t/R$

190） 磁極（じきょく）= magnetic pole = a region of a magnet at which magnetism (磁気) is concentrated (集中している). There are 2 kinds of magnetic poles, the north (N 極) and the south (S 極) pole.

191） 磁気力(じきりょく) = magnetic force = the attractive (引力) or repulsive (斥力) force exerted (およぼされる) between magnetic poles

192） 磁場（じば）磁界（じかい）= magnetic field = the region of space (空間) around a magnet where a magnetic force is exerted

193） 磁場の向き（じばのむき）= direction of magnetic field = By convention (慣習により), the field direction goes outward from the north pole and into the south pole of the magnet (磁石). The north indicator of the compass (方位磁針の N 極) is a magnetic north pole, so the north indicator of the compass will point toward the south pole of a magnet because unlike (opposite) magnetic poles attract. (A compass will point toward the magnetic pole in northern Canada because it is a magnetic south pole.) (The magnetic south pole is approximately 1,500 km from the Earth's geographic North pole.)

194） 磁力線（じりょくせん）= magnetic field lines = imaginary lines (仮想の線) representing (表す) a magnetic field. Magnetic field lines appear to begin at the north pole of a magnet and to end at the south pole of a magnet (magnetic field lines come from the north pole and go into the south pole of a magnet). Magnetic field lines have the direction that a compass needle (方位磁針) would point at each location.

195) 右ねじの法則（みぎねじのほうそく）= right-hand rule (right-hand grip rule) = To find the direction of the magnetic field around a current-carrying wire, mentally grasp the wire in your right hand with your thumb extended (伸ばした親指), pointing in the direction of the current. When you grip the wire with your other 4 fingers, they will naturally curl around in the direction of the magnetic field lines.

196) ソレノイド = solenoid = a coil of wire helically (spirally) (らせん状に) wound (巻かれた), becoming an electromagnet (電磁石) when a current is passed through it

197) 電磁石（でんじしゃく）= electromagnet = a solenoid with an intensified (強化された) magnetic field by the insertion (挿入) of ferromagnetic materials (強磁性体) such as iron (鉄=Fe), cobalt (コバルト=Co), and nickel (ニッケル=Ni)

198) 電磁誘導(でんじゆうどう) = electromagnetic induction = the process of inducing (誘導する) a current in a circuit (without the use of a battery or electrical power supply) by changing the magnetic field that passes through the circuit (回路)

199) 誘導起電力（ゆうどうきでんりょく）= induced electromotive force (emf) = potential difference generated (生じる) by electromagnetic induction (電磁誘導)

200) 誘導電流（ゆうどうでんりゅう）= induced current = an electric current resulting from (結果として) an induced electromotive force

201) 直流電流（ちょくりゅうでんりゅう）= direct current = an electric current from a power supply (e.g. battery where power flows out of the positive terminal through the circuit (回路) and flows into the negative terminal) that flows in a fixed direction (一定の向き) in a circuit. The electrons move in the opposite direction.

202) 交流電流（こうりゅうでんりゅう）= alternating current = an electric current from a power supply that changes direction of flow periodically (周期的に変化する電流) (frequency in hertz e.g., 60Hz in west Japan and the U.S.). The terminals of the source of potential difference are constantly changing sign (positive to negative and back again).

203) 交流発電機（こうりゅうはつでんき）= alternating-current generator = machines (used in many electric power plants (発電所)) where wire coils inside are made to rotate (回転する) within an electric field (電場). This way alternating current is induced.

204) 周期（しゅうき）= period = the length of time in seconds that the waveform takes to repeat itself from start to finish (time for one complete cycle)

205) 周波数（しゅうはすう） = frequency = the number of times the waveform repeats itself within one second measured in hertz (Hz)

206) 実効値（じっこうち）= effective value (root-mean-square value) = the value of alternating current that gives the same heating effect that the corresponding value of direct current does.
average power: $P = I_{rms} \cdot V_{rms}$
rms current: $I_{rms} = I_{peak}/\sqrt{2}$
rms voltage: $V_{rms} = V_{peak}/\sqrt{2}$

207) 変圧器（へんあつき）（トランス）= transformer = a device that increases or decreases the emf of alternating current (i.e., one voltage is transformed to another voltage) by electromagnetic induction without change of frequency

208) 整流（せいりゅう）= rectification = process in which alternating current is allowed to flow only in one direction (by using an electrical device called a rectifier such as a semiconductor diode which allows current to flow in one direction only)

Note: an important process since almost all electrical power is supplied as alternating current, but many devices like electric motors and TV sets use direct current

209) 電磁波 (でんじは) = electromagnetic wave = a periodic, transverse wave (横波) (energy) radiated (放射する) with a constant speed of 3.0 × $10^8$ m/s in a vacuum (slower if material is present). It is radiated from an accelerating charge. An electromagnetic wave consists of electric and magnetic field waves at right angles to each other. The wave moves in the direction perpendicular to both oscillating waves.

210) 電磁波の分類（でんじはのぶんるい）= classification or types of electromagnetic waves from lowest energy/longest wavelength to highest energy/shortest wavelength:

- 電波（でんぱ）= radio waves
  (range 範囲: λ>30cm) (e.g., AM/FM radio, television, radar)

- マイクロ波 = microwaves
  (range 範囲: 30cm>λ>1mm) (e.g., microwave ovens, cell phones, wireless network)

- 赤外線（せきがいせん）= infrared waves (rays)
  (range 範囲: 1mm>λ>700nm) (any object that has a temperature above -273.15 degrees Celsius (absolute zero) like ice cube, hot charcoal, human body, or TV remote control)

- 可視光線（かしこうせん）= visible light
  (range 範囲: 700nm(red)>λ>400nm(violet)) (e.g., rainbow colors, projector, flashlight, headlight, computer screen)

- 紫外線（しがいせん）= ultraviolet rays or UV rays
  (range 範囲: 400nm>λ>60nm) (used for sterilization (消毒) of medical instruments (医療機器)

- X 線 = X-rays
  (range 範囲: 60nm>λ>$10^{-4}$nm) (used for medical examination of bones, teeth, and chest)

- γ 線 = gamma rays
  (range 範囲: 0.1nm>λ>$10^{-5}$nm) (used for treatment of cancer (がん治療) and examination of thick materials for structural defects(構造欠陥))

## エネルギーとその利用 (Energy and Its Applications)

211) 化石燃料（かせきねんりょう）= fossil fuels = fuels (e.g., oil, coal, and natural gas) formed from the remains (遺骸) of very old living organisms (太古の生物) that have high carbon (炭素) or hydrogen (水素) content and used as energy sources

212) バイオマスエネルギー = biomass energy = energy derived from (得られる) fuel converted from (変換された) living, or recently living biological organisms (有機物) such as plant materials, by-products (副産物) (e.g. animal fat) and waste from livestock farming (家畜の糞尿), food processing (調理) and preparation, and domestic organic waste (生ごみ)

213) 元素（げんそ）= element = a substance (物質) that cannot be broken down (分解する) into simpler substances by chemical means. All the atoms of an element have the same number of protons or electrons, but the neutrons may vary (異なる).

214) 原子番号（げんしばんごう）= atomic number = the number of protons in an atom's nucleus (equal to the number of electrons orbiting (周回する) the nucleus in a neutral atom (中性原子)

215) 質量数（しつりょうすう）= mass number = the sum of the number of protons and neutrons in a nucleus

216) 同位体（どういたい）（アイソトープ）= isotope = an atom that has the same atomic number but different atomic mass (have the same number of protons but different number of neutrons in the nucleus ) as other atoms of the same element

217) 放射線（ほうしゃせん）= radiation = the emission (放射) of energy as photons or particles from a radioactive source. High-energy particles and photons can cause ionization (電離作用). There are 3 types of radiation emitted by a nucleus: alpha particles, beta particles, and gamma rays.

218) 放射性崩壊（ほうしゃせいほうかい）= radioactive decay = process by which a nucleus of an unstable (不安定) atom loses energy by emitting (放出する) an alpha or beta particle sometimes followed by a gamma-ray photon

219) 放射性同位体（ほうしゃせいどういたい）= radioisotope = an isotope of an element that is radioactive (放射性がある)

220) 崩壊（ほうかい）= decay = spontaneous transformation (自発的な変化) of a radioactive nuclide (parent: 親核種) into another radioactive or non-radioactive nuclide (daughter: 娘核種) with the emission (放出) of one or more particles or photons

221) α崩壊 = α-decay = emission (放出) with around 1/20$^{th}$ the speed of light of an alpha particle (identical to a $^{4}_{2}He$ nucleus from an unstable nuclide (核種)) made up of 2 protons and 2 neutrons.

222) β 崩壊 = β-decay (beta minus decay) = emission of a beta particle (one of the neutrons is converted into a proton, which remains in the nucleus). An electron, the beta minus particle, is ejected during the transformation (変換) from the neutron that converted into a proton. Usually occurs with nuclides(核種) for which the neutron-to-proton ratio N/Z is too large for stability (安定性). The neutron number decreases by 1, the proton number increases by 1, and the mass number does not change.

β 崩壊 = β+decay (beta plus decay) = emission of a beta-plus particle (positron: positively charged electron). Nuclides for which the neutron-to-proton ratio N/Z is too small for stability (安定性) can emit a positron. A proton is converted into a neutron in the nucleus.

223) 電子捕獲崩壊（でんしほかくほうかい）= electron capture (inverse beta decay) = Happens when the decay of the neutron is reversed, that is, when an electron penetrates (貫通する) the nucleus of an atom and interacts with a bound (束縛された) proton to form a bound neutron (the nucleus loses a proton and gains a neutron).

224) γ 崩壊 = γ-decay = transition (遷移) of the nucleus to a lower energy state (状態) by the emission (放出) of a gamma ray (photon: a kind of electromagnetic wave) from an unstable nuclide. It has no mass or electric charge and no effect on the mass number A or atomic number Z of a nucleus.

225) ベクレル＝becquerel = SI unit (Bq) of radioactivity (放射能). One becquerel is equal to the decay (崩壊) of one atom of a radioisotope (放射性同位体) per second. A kilogram or a liter sample emitting (放出する) radiation from one hundred decays per second is said to have a radioactivity of 100 becquerels/kg or liter.

226) グレイ＝gray = SI unit of absorbed dose (吸収線量)when one kilogram of matter (物質) absorbs one joule (1J/kg) of ionizing radiation (電離放射線) (replacing the rad: 1Gy = 100 rad). The absorbed dose depends on the strength of a given radiation beam (放射線ビーム) and the type of material absorbing (吸収する) the radiation. It does not tell how much damage (損傷) is done to a body since different types of radiation cause different amounts of damage for the same absorbed dose.

Note: (equivalent dose (等価線量) in mSv) = (absorbed dose (吸収線量)) × (radiation weighting factor (放射線荷重係数))

Note: (effective dose 実効線量 in mSv) = Σ [(equivalent dose) × (tissue weighting factor (組織荷重係数))]

Note: Effective dose is a quantity calculated (計算する) by multiplying the equivalent dose received by every significantly irradiated tissue (照射を受けた組織) in the body by a respective tissue weighting factor (それぞれの組織荷重係数).

Note: radiation weighting factor (放射線荷重係数):
(e.g. 1 for beta and gamma radiation and 20 for alpha radiation: 20 times as much biological damage (生物学的損傷) as the same dose of beta or gamma radiation)

Note: tissue weighting factor (組織荷重係数):
(e.g., 0.12 for bone marrow (骨髄), 0.01 for bone surface, 0.05 for liver (肝臓), and 0.12 for stomach (胃))

227) シーベルト= sievert = SI unit of radiation dose equivalent: (replacing the rem: 1Sv = 100 rem), a measure of the amount of potential damage (潜在的な損傷) to the body from a given amount of radiation.
(e.g., average natural radiation exposure per person in Japan per year = 1.5 mSv, world average = 2.4 mSv: 1.2mSv from radon gas, 0.5mSv from the ground/earth, 0.4 mSv from space, and 0.3 mSv from food and drinks)

228) 中性子線（ちゅうせいしせん）= neutron beam = a stream (流れ) of subatomic particles (neutrons) that have no electric charge and emitted during radioactive decay (can also be generated by special radiation equipment). Beams of neutrons from nuclear reactors (原子炉) are used to bombard (照射する) the atoms of elements (e.g., uranium-235 and plutonium-239) to produce fission.

229) 電離作用（でんりさよう）= ionization = ionizing radiation (alpha particles, beta particles, gamma rays and X-rays) strips or removes electrons (電子をはじき出す) from atoms. The process of ionization can break the chemical bonds (結合) between atoms in molecules (分子).

230) 半減期（はんげんき）= half-life = the time it takes for one-half of the original nuclei of a radioactive substance (radioisotope 放射性同位体) to decay (崩壊する)
(e.g., $^{238}$U (uranium-238) = 4.47 billion years, $^{14}$C (carbon-14) = 5,730 years, $^{137}$Cs (cesium-137) = 30.2 years, $^{131}$I (iodine-131) = 8 days, $^{222}$Rn (radon-222) = 3.8 days, $^{220}$Rn (radon-220) = 55.6 seconds)

231) 核エネルギー = nuclear energy = the energy obtained (得る) from reactions within atomic nuclei as a result of nuclear fission (核分裂) or fusion (核融合) (e.g., used as a source of power for generating electricity)

232) 核分裂(かくぶんれつ)= nuclear fission = a decay process in which an unstable nucleus (e.g. uranium-235 and plutonium-239) splits (分裂する) into two smaller nuclei. (e.g., uranium-235 fission due to absorption of a slow neutron by a nucleus, releasing energy (gamma rays) and several free neutrons in the process)

233) 核融合（かくゆうごう）= nuclear fusion = reaction with extremely high temperature where two or more small light nuclei come together (fuse) to form a larger nucleus (e.g., hydrogen-1 and hydrogen-2 fusion reaction requiring about 50 million degrees Celsius to form a larger nucleus of helium atoms with the accompanying (伴って) release of energy) (source of energy for the stars and the sun)

234) 連鎖反応（れんさはんのう）= chain reaction = One fission event must trigger (引き金となる) others so that the process spreads (広がる) throughout the nuclear fuel (e.g., fission (核分裂) of a uranium nucleus caused by neutron bombardment (照射), releasing other neutrons that can trigger more fissions). The reaction may be made to proceed (進行する) slowly in a controlled way in a nuclear reactor or explosively (爆発的) in a bomb.

235) 臨界（りんかい）= criticality = point at which a nuclear chain reaction (連鎖反応) has reached self-sustaining (自己持続) level with sufficient (十分な) fissionable material (核分裂性物質).

## USEFUL PHRASES AND EXPRESSIONS IN THE CLASSROOM (for teacher use) :

1. Let's begin today's class.
2. Let's review yesterday's/last week's lesson.
3. Raise your hand if you know the answer/if you have a question.
4. Please answer the question if you know the answer.
5. Please solve the problem. Can you solve the problem?
6. Discuss with your seatmate(s) next to/behind/in front of you.
7. Add, subtract, multiply, divide, calculate
8. What is the difference between _____and_____?
9. The English word for _____ is _____.
10. Go/turn to page 10 and look at the graph /diagram/table.
11. Please answer in a loud voice.
12. Can you speak loudly please?
13. Speak louder please.
14. Please repeat the answer.
15. Now everybody listen. This is very important.
16. Please pay attention to this.
17. Listen to me.
18. Look at the board/screen.
19. Sorry, I did not hear your answer/what you said.
20. Sorry, I cannot hear you. Can you speak up?
21. How many of you know the answer?
22. Don't forget to (do your homework/bring your book).
23. Can you distinguish /see the difference between A and B?
24. Stop writing, and everybody look at the board.
25. Can I have your attention please?
26. Don't look at the notes/answer of your seatmate.
27. Who doesn't/ did not understand my explanation?
28. Repeat after OO-sensei

29. Take your time.
30. Write this down.
31. Can you follow my explanation/equation?
32. Now you see why X is equal to Y.
33. If we add 1 plus 2, we get 3.
34. Do you know the solution to this equation?
35. Is this too difficult?
36. Sorry, I don't understand what you said/are saying.
37. Can you repeat that/say that again please.
38. Can you explain why this is so?
39. Did you do your homework that I gave you last Friday?
40. Do not do your homework in this class.
41. Who originally did the homework?
42. Please go back to your seat.
43. Can you explain what/which/why _____?
44. Can you explain your answer?
45. Can someone/anybody tell me what/which/why_____?
46. Go back/turn back to page 13.
47. Numerical value (数値)
48. Frame of reference (基準系)
49. Observer (観測者)
50. Formula (公式)
51. Hypotenuse (斜辺) of the right triangle (直角三角形)
52. X-axis (horizontal line), X-coordinate or value
53. Y-axis (vertical line), Y-coordinate or value
54. Let's plot the points on the graph/diagram.
55. Coordinates of point A are 10 and 30 (for X and Y axes)
56. Origin = point (0.0) where the 2 axes intersect
57. equilibrium=つりあい
58. The square root of 4 is 2. / The cube root of 8 is 2 (8 の三乗根は 2 です).
59. 2 (multiplicand) × 3 (multiplier) = 6 (product)
60. 6 (dividend) ÷ 3 (divisor) = 2 (quotient)

61. 3 (addend) + 2 (addend) = 5 (sum or total)
62. 5 (minuend) – 3 (subtrahend) = 2 (difference or remainder)
63. 1/2：numerator/denominator
64. $7^2$：7 squared
65. $7^3$：7 cubed
66. $7^4$：7 to the fourth, 7 raised to the $4^{th}$ power, 7 to the power of 4, 7 raised to the power of 4
67. $7\times10^5$：seven times ten to the fifth
68. $7\times10^{-5}$：seven times ten to the minus (negative) five
69. A＞B：A is greater than B (or B is less than A)
70. numbers known in formulas/equations = known or given values
71. Please solve for X in this equation.
72. Let's find/look for the value of X.
73. Now we get the answer/solution: X is 1.
74. We can now substitute 1 and 2 for X.
75. What does this indicate/show?
76. Solve this problem using/following the same equation /process.
77. Simplify the equation.
78. Substitute the values into the equation.
79. Substitute the numbers for the letters in the formula.
80. I cannot prove it/ I cannot show you the proof.
81. Choose the one that you like/want.
82. Decompose the vector into components.
83. Write this important formula on the board/ in your notebooks.
84. Erase this part.
85. Dotted and solid lines = 破線 and 実線
86. Auxiliary line＝補助線
87. Rhombus or parallelogram=平行四辺形
88. Trapezoid = 台形
89. Please come to the front/to the board.

90. Please take a seat/your seats.
91. Let's clear the table.
92. Return everything back to where they are kept.
93. That is the right/wrong answer.
94. The 2 lines are parallel/perpendicular to each other.
95. I'll give you more time to think about it.
96. Please tell/show me/us the answer.
97. Now, I'll ask you some questions about_____.
98. Get into groups of 4. （4人ずつのグループになりましょう）
99. Do it yourself/as a group.
100.Let's stop here. That's all for today. Class dismissed.

Prepared and Compiled by:

【作成者】

岡山県立倉敷天城高等学校
講　　師　　ラモン ファーガス：Ramon Fargas　（2013―2014）
指導教諭　　仲達修一：Shuichi Nakadachi　（2013―2014）
ＧＳＯ非常勤講師　白神陽一朗：Yoichiro Shirakami　（2013―2014）
ＧＳＯ非常勤講師　ディヴィナ：Divina Gracia Jazareno　（2013）
（岡山大学　教員研修留学生）

ＧＳＯ非常勤講師は，岡山県教育委員会の事業である「グローバル・サイエンスＯＫＡＹＡＭＡ」により配置された講師です。

【協力者】

岡山県立岡山一宮高等学校
教　　諭　　生部昭光：Akimitsu Shobe　（2013）
（現：岡山県立総社高等学校）

【参考文献：Reference books】

・中村英二 他：高等学校 物理基礎（第一学習社，2012）
・國友正和 他：物理基礎（数研出版，2012）
・藤澤皖，北村俊樹：英和学習基本用語辞典 物理（アルク，2009）
・University Physics, H. Young and R. Freedman (13th edition, 2012 Pearson Education, Inc.)
・Physics, R. Serway and J. Faughn (2009 Holt, Rinehart and Winston)
・Principles of Physics, Jearl Walker (9th edition, 2011 John Wiley and Sons, Inc.)
・Inquiry into Physics, V. Ostdiek and D. Bord (7th edition, 2013 Brooks/Cole Cengage Learning)
・Physics (Principles and Applications), D.C. Giancoli (2014 Pearson Education, Inc.)

# 岡山県立倉敷天城高等学校

Okayama Prefectural Kurashiki Amaki Senior High School

〒710-0132　　岡山県倉敷市藤戸町天城２６９番地

Zip code：　710-0132

269 Amaki Fujito-cho, Kurashiki-shi, Okayama-ken, Japan

TEL　086-428-1251　　FAX　086-428-1253

URL　http://www.amaki.okayama-c.ed.jp/

e-mail　amaki@pref.okayama.jp　（学校代表）

amaki-ssh@pref.okayama.jp　（ＳＳＨ）