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“For there was never yet philosopher that could endure the toothache patiently.”

William Shakespeare, Much Ado About Nothing



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Editor's Note

Effective education in the modern era demands pedagogical approaches that transcend the mere delivery of knowledge and instead foster learners' capacity to connect and integrate diverse concepts. Interdisciplinary and integrated instruction has therefore emerged as a credible and practical framework for uniting theoretical insight with real-world application, deepening understanding while inspiring greater motivation to learn. The CCK CLERESTORY, a scientific and educational journal, aspires to become a structured and authoritative resource for school-based education. Each issue focuses on a central theme, around which subjects from various fields, including mathematics, physics, chemistry, history, and beyond, are presented in harmony with curricular objectives and the chosen topic.

In this first issue, the central theme is the tooth and dentistry. Accordingly, every problem and educational piece included here places the tooth or dentistry at the center, using this central theme as a lens through which concepts are framed, explored, and connected across disciplines.

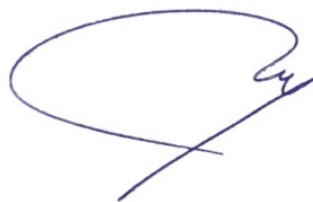
In architecture, a *clerestory* is a high window that admits light from above into the interior of a building. We chose this name as a metaphor for opening elevated "windows of knowledge" into the classroom, letting in light that connects disciplines, reveals underlying relationships, and makes abstract ideas more visible and accessible to learners.

Beyond its print edition, The CCK CLERESTORY introduces a complementary digital platform that hosts carefully reviewed educational problems and materials designed to help teachers demonstrate how academic knowledge translates into real-world contexts.

Through the continued participation of educators and readers, The CCK CLERESTORY seeks to evolve into a lasting repository of interdisciplinary learning resources that demonstrate their relevance to everyday life.

Sincerely,

Dr. Kamal Shahtalebi
Editor-in-Chief

A handwritten signature in blue ink, consisting of a large, stylized loop followed by a horizontal line and a small flourish.

Physics and Mathematics in Dental Molding

1) Background

Dental impression taking is one of the crucial steps in the fabrication of prostheses, crowns, or veneers. In this process, a flexible and moldable material, such as silicone, alginate, or polyether, is placed over the tooth to obtain an accurate impression of the tooth surface and surrounding gingiva.

Once the material sets, the impression is removed from the patient's mouth and then used to produce a plaster or resin model for further prosthetic fabrication.

The main characteristics of impression materials include:

- Proper viscosity and flowability to capture fine details of the tooth crown,
- Controlled setting time to allow adequate manipulation before hardening,
- Dimensional stability after setting to ensure accurate prosthesis production.



2) Problem Statement

- a) A tooth can be modeled as a cylinder with a height of 10 mm and a base radius of 5 mm, topped by a conical tip with a height of 5 mm. Calculate the volume of the cavity formed in the impression material
- b) If the impression volume is 2 cm^3 and its density is 1.2 g/cm^3 , determine the mass of material required for the impression.
- c) During the setting period, the material transitions from viscous to solid. If the viscosity increases from $500 \text{ Pa}\cdot\text{s}$ to $5000 \text{ Pa}\cdot\text{s}$ over 2 minutes, what is the rate of change of viscosity in $\text{Pa}\cdot\text{s/s}$?
- d) Suppose the impression begins to set at 25°C and the heat released by the reaction is 5 J . If the material's specific heat capacity is $1.5 \text{ J}\cdot\text{g}^{-1}\cdot^\circ\text{C}^{-1}$, what is the temperature rise, assuming an impression volume of 2 cm^3 ?
- e) Optional: Assume the impression material is alginate and its setting can be modeled as a first-order reaction. Using the data from part (c) and assuming a final viscosity of $6000 \text{ Pa}\cdot\text{s}$, determine the rate constant for setting.



3) Solution

- a) The volume of the cylindrical part of the tooth is:

$$V_1 \approx \pi r^2 h = 3.1416 \times 0.5^2 \times 1 \approx 0.785 \text{ cm}^3$$

and the volume of its conical tip is:

$$V_2 = 1/3 \pi r^2 h = 1/3 \times 3.1416 \times 0.5^2 \times 0.5 \approx 0.131 \text{ cm}^3$$

Thus, the total volume of the tooth, and therefore the volume of the cavity formed in the impression, is: $0.785 + 0.131 = 0.916 \text{ cm}^3$

- b) The mass of the impression material is: $m = 2 \times 1.2 = 2.4 \text{ g}$

- c) The change in viscosity ($\Delta\eta$) is: $\Delta\eta = 5 \times 10^3 - 500 = 4500$

This change occurs over the time interval Δt : $\Delta t = 2 \text{ min} = 120 \text{ s}$

Therefore, the rate of change is: $\Delta\eta/\Delta t = 4500 / 120 \approx 37.5 \text{ Pa} \cdot \text{s/s}$

- d) The heat released is given by $Q = mc\Delta T$; hence: $\Delta T = Q / mc$

The mass of the impression is $m = 2 \times 1.2 = 2.4 \text{ g}$, therefore:

$$\Delta T = 5 / (2.4 \times 1.5) \approx 1.4 \text{ }^\circ\text{C}$$

- e) Based on the given data, with η_0 and η_∞ denoting the initial and final viscosities, respectively, the change in viscosity, under the assumption of first-order behavior, can be modeled as an exponential approach toward the final value:

$$\frac{d\eta}{dt} = k(\eta_\infty - \eta) \Rightarrow \eta(t) = \eta_\infty - (\eta_\infty - \eta_0)e^{-kt}$$

Therefore:

$$k = -\frac{1}{t} \ln \left(\frac{\eta_\infty - \eta(t)}{\eta_\infty - \eta_0} \right)$$

By substituting the given data from part c:

$$k = -\frac{1}{120} \ln \left(\frac{6000 - 5000}{6000 - 500} \right) = \frac{1}{120} \ln \left(\frac{11}{2} \right) \approx 0.0142 \text{ s}^{-1}$$

The time constant of the process is the reciprocal of k and equals $\tau = 1/k \approx 70.4 \text{ s}$.



4) Conclusion

The following concepts are integrated into this interdisciplinary problem, with several of them aligned with the British Columbia Curriculum:

- Spatial geometry and volumes (cylinder and cone)
- Unit conversion, density, and the relation $m = \rho V$
- Heat and thermodynamics (calorimetry ($Q = mc\Delta T$))
- Viscosity and rheological behavior of materials
- Rate of change and average rate of change
- First-order reaction kinetics (exponential model $\eta(t) = \eta_{\infty} - (\eta_{\infty} - \eta_0)e^{-kt}$)
- Exponential and logarithmic functions

Curriculum Alignment – British Columbia (Sample Mapping)

Workplace Mathematics 10	Volume of 3D objects, cylinders, measurement, and unit conversions
Pre-Calculus 12	Exponential and logarithmic functions
Calculus 12	Average rate of change
Physics 11	Thermal equilibrium, specific heat capacity, and calorimetry
Chemistry 12	Reaction rates and energy changes in chemical systems

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- [2] P. Atkins, J. de Paula, and J. Keeler, *Atkins' Physical Chemistry*, 12th ed. Oxford, U.K.: Oxford University Press, 2022.
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According to historical records, Philipp Pfaff, a German dentist, described an early dental impression technique in 1756 using softened wax and plaster of Paris to produce dental casts. His work represents an important milestone in the development of modern dental impression techniques.



Chain Polymerization and Its Role in Dental Filling

1) Background

In dental clinics, resin-based composites are commonly used to restore decayed teeth. Once placed in the prepared cavity, these materials can be hardened by exposure to blue light, which activates a photoinitiator system within the resin.

One of the principal resin monomers used in dental composites is Bisphenol A-glycidyl methacrylate (Bis-GMA). Bis-GMA contains two polymerizable methacrylate groups, each with a carbon-carbon double bond. When the photoinitiator system is activated by blue light, free radicals are generated. These radicals initiate polymerization of the methacrylate groups, leading to the formation of a three-dimensional cross-linked polymer network.

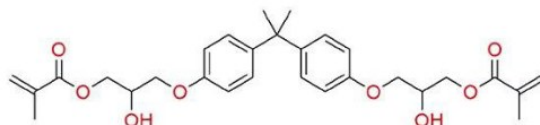
This polymerization process transforms the initially moldable resin into a rigid restorative material, helping restore the shape and function of the tooth while providing the mechanical strength and durability required for clinical use.

Considering these concepts, and in alignment with Grade 11 Chemistry curriculum topics related to organic compounds and polymers, an applied problem is presented in Section 2, followed by its solution in Section 3.



2) Problem Statement

In dentistry, resin-based composites used for tooth restoration contain monomers such as Bis-GMA (see figure below). Bis-GMA contains two polymerizable methacrylate groups, each with a carbon-carbon double bond. During curing, blue light activates a photoinitiator, generating free radicals that initiate free-radical addition polymerization.



A simplified representation of the monomer is shown below:



In this structure:

- $\text{CH}_2=\text{C}(\text{CH}_3)-\text{C}(=\text{O})-\text{O}-$: methacrylate group
- $-\text{C}(=\text{O})-\text{O}-$: ester linkage
- R: central Bis-GMA backbone

- Identify the type of polymerization reaction for this material and explain why.
- State one advantage of using photoinitiated polymerization in dentistry from the standpoint of safety and efficiency.
- Write the overall free-radical addition polymerization reaction for this monomer in a schematic, simplified form (using n and $\rightarrow$).
- If the molar mass of the Bis-GMA monomer is 512 g/mol, answer the following:
 - How many moles of monomer are present in 5.12 g of this substance, and how many molecules does this correspond to?
 - For a simplified mass-conservation model, assume that 20 Bis-GMA monomer units form one polymer segment. What is the molar mass of this polymer segment, and what mass of polymer is formed from 5.12 g of monomer? Explain how the result demonstrates conservation of mass.
- What is the role of blue light in this process, and why is its use preferred over ultraviolet (UV) or red light?



3) Solution

a) Type of Reaction and Reason

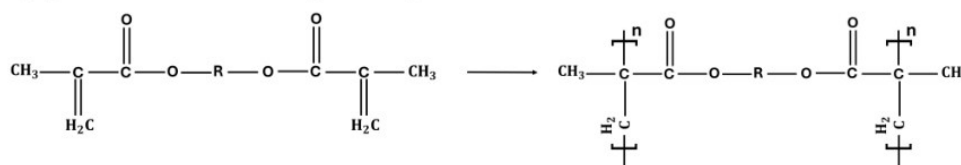
Type of Reaction: *Free-radical addition polymerization*

Reason: Bis-GMA contains two methacrylate groups with polymerizable carbon-carbon double bonds. Blue light activates the photoinitiator system, generating free radicals that initiate polymerization and link neighboring monomers into a cross-linked network without releasing small-molecule by-products.

b) Advantage

Light-activated polymerization allows the dentist to control when curing begins and provides working time to shape the restoration. It proceeds under clinical conditions without external heating.

c) Overall (Symbolic and Simplified) Reaction



The left structure represents the Bis-GMA monomer. During polymerization, its terminal carbon-carbon double bonds form covalent links, producing a three-dimensional cross-linked network, shown schematically on the right.

d) Amount of Substance, Number of Molecules, and Mass

d-1) The number of moles of monomer in 5.12 g is: $n_{\text{monomer}} = \frac{5.12 \text{ g}}{512 \text{ g/mol}} = 0.01 \text{ mol}$

Number of molecules: $0.01 \times 6.022 \times 10^{23} = 6.022 \times 10^{21}$ molecules

d-2) For the simplified model, the molar mass of a 20-unit polymer segment is:

$$M_{\text{segment}} = 20 \times 512 \text{ g/mol} = 10,240 \text{ g/mol}$$

The equivalent amount of 20-unit polymer segments formed from 0.01 mol of monomer is: $n_{\text{segment}} = \frac{0.01}{20} = 5 \times 10^{-4} \text{ mol}$

Therefore, the mass of the polymer is:

$$m_{\text{polymer}} = M_{\text{segment}} \times n_{\text{segment}} = 10,240 \times (5 \times 10^{-4}) = 5.12 \text{ g}$$

This value equals the mass of the initial monomer, demonstrating conservation of mass.



e) The Role of Blue Light

Blue light is well suited for curing dental composites because of the following characteristics:

- **Suitable wavelength for photoinitiator activation:** Many dental composites contain camphorquinone, which absorbs blue light most effectively around 470 nm. This light activates the photoinitiator system and generates free radicals that initiate polymerization.
- **Effective curing:** Blue light provides an appropriate combination of wavelength and penetration for curing resin composites. UV light has higher photon energy but poses greater biological risks, while red light is poorly absorbed by camphorquinone and is therefore ineffective for CQ-based curing.
- **Clinical safety:** Blue light is generally safer than UV radiation for biological tissues; however, direct viewing of curing lights should be avoided and appropriate eye protection is recommended.
- **Controlled reaction timing:** Polymerization begins when the curing light is applied, giving the dentist sufficient working time to shape and position the composite before curing.

4) Conclusion

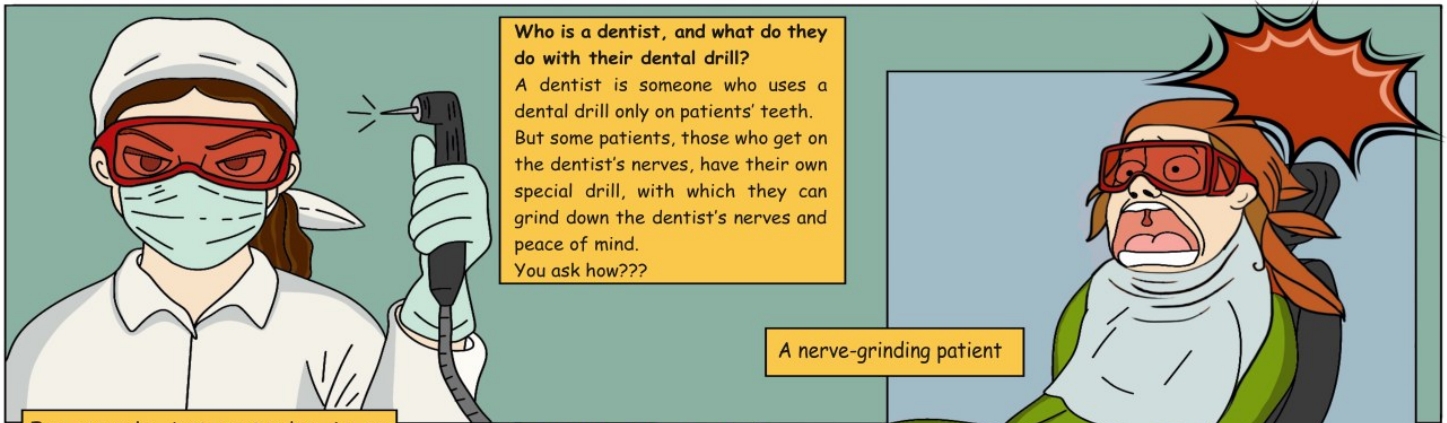
This problem uses a tangible dental application to reinforce free-radical addition polymerization, the applications of polymers, symbolic representation of chemical reactions, mole and mass calculations, and the connection between scientific knowledge and dental applications.

Curriculum Alignment – British Columbia (Sample Mapping)

Chemistry 12	Reaction mechanisms and factors affecting reaction rate
Chemistry 11	Organic compounds and applications of organic chemistry, including polymers; mole and mass calculations; Avogadro's number and number of molecules; representation of chemical reactions
Science 8	Electromagnetic energy and the properties and behaviour of visible light

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- [4] A. Peutzfeldt, "Resin composites in dentistry: The monomer systems," *European Journal of Oral Sciences*, vol. 105, no. 2, pp. 97–116, 1997.
- [5] F. A. Rueggeberg, "State-of-the-art: Dental photocuring—A review," *Dental Materials*, vol. 27, no. 1, pp. 39–52, 2011.



Who is a dentist, and what do they do with their dental drill?
A dentist is someone who uses a dental drill only on patients' teeth. But some patients, those who get on the dentist's nerves, have their own special drill, with which they can grind down the dentist's nerves and peace of mind. You ask how???

A nerve-grinding patient

For example, just yesterday, in my Buddhist calm, working on a perfectly non-annoying patient, gently treating a decayed tooth with my dear drill...

Suddenly, the whole office shook with a thunderous noise.

A man, shouting, entered while holding a young boy's hand and dragging him along...



The way he stretched the kid's mouth from both sides, I could almost hear the muscles in his face tearing...



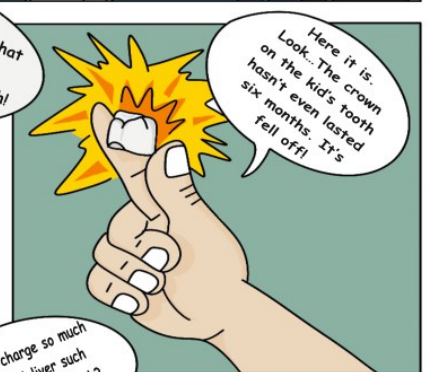
Heey!



How is this the tooth you worked on in my kid's mouth?!



Now, don't go so far that the kid ends up with neither teeth nor a mouth! What's the problem?



Here it is. Look. The crown on the kid's tooth hasn't even lasted six months. It's fell off!

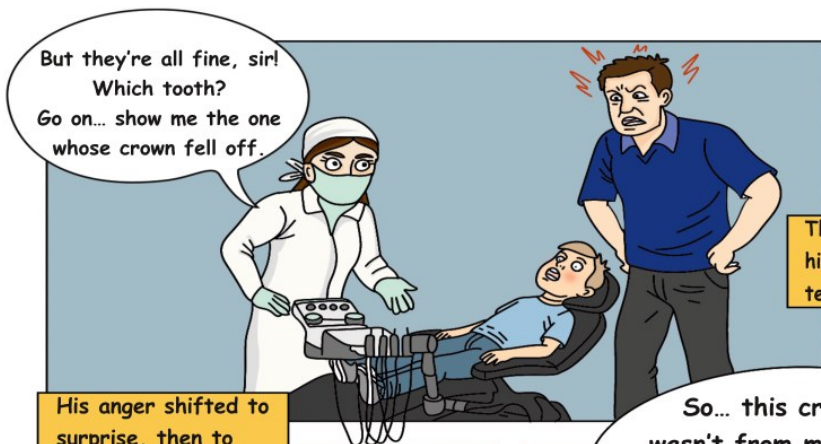
You charge so much and deliver such poor-quality work?



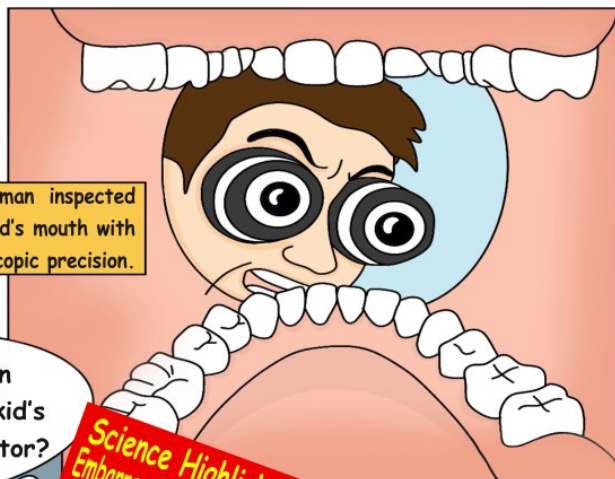
Open your mouth for me, please.

I examined the teeth carefully. There was no sign of any crown having fallen off. Everything was perfectly intact — just like the day it was first placed.

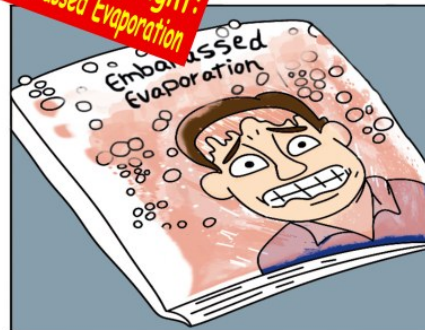




The man inspected
his kid's mouth with
telescopic precision.



Science Highlight:
Embarrassed Evaporation



His anger shifted to
surprise, then to
embarrassment.

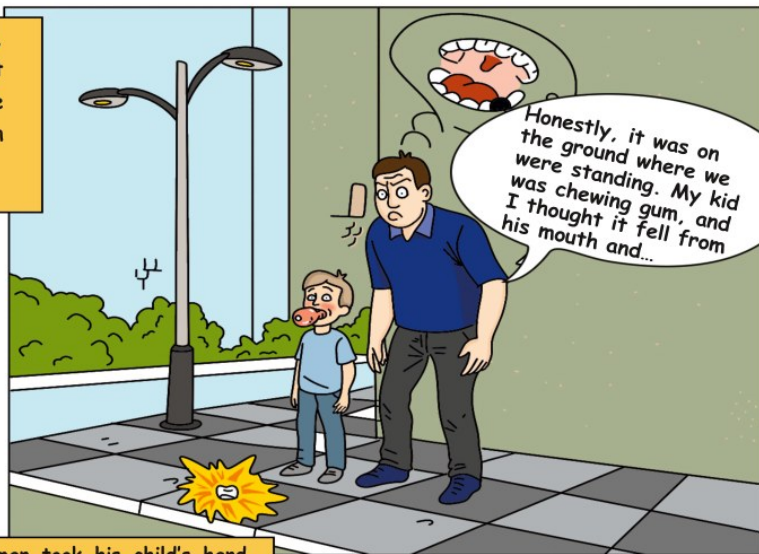


So... this crown
wasn't from my kid's
tooth at all... doctor?

In all that righteous fury,
I wasn't thinking about
drilling a tiny hole in the
kid's dad's head... I was in
heaven!



So where did
you get this
crown from?



Honestly, it was on
the ground where we
were standing. My kid
was chewing gum, and
I thought it fell from
his mouth and...

The man took his child's hand,
patted his head, bribed him not
to tell his mother, and walked
out of the clinic.



I'm sorry, that
was rude of me.



Dental Turbine: Speed, Pressure, and Energy



1) Background

The dental turbine is a high-speed instrument used for tooth cutting and preparation. The bur attached to the turbine transfers mechanical energy to the tooth, enabling the removal of hard dental tissue. Its high rotational speed allows efficient cutting and can reduce treatment time while improving precision. Because cutting generates heat, adequate cooling and careful safety control are essential during use.

Dental turbines are typically air-driven and powered by compressed air. Their lightweight rotors can rotate at hundreds of thousands of revolutions per minute (rpm). The main components of a dental turbine include:

- **Air Supply:** Delivers compressed air from the dental unit to the turbine head. Air pressure and flow rate must be properly regulated to maintain suitable rotational speed and performance.
- **Drive Air Nozzle:** Directs compressed air onto the turbine blades, generating torque and causing the rotor and shaft to rotate at high speed.
- **Exhaust Port:** Carries the spent air away after it passes through the turbine rotor. In some designs, the exhaust airflow may contribute slightly to cooling the turbine head, while cooling of the tooth and bur is primarily provided by a water spray.
- **Rotor and Bur:** The rotor is the main rotating component in the turbine head and contains blades that receive the drive air and convert its energy into rotational motion. The bur, mounted on the rotor shaft, performs cutting, grinding, or polishing of dental tissue.

- **Spindle / Shaft:** The central axis on which the bur is mounted. Its rotation enables cutting and shaping of the tooth. The shaft is supported by bearings, allowing it to spin with minimal friction.
- **Disc (Turbine Wheel / Impeller):** Transfers the energy of the driving air to the rotor and shaft. It typically contains impeller blades that direct airflow efficiently. In some designs, the disc is multi-layered or equipped with special blade geometries to enhance performance.
- **Bearings:** Reduce friction and stabilize the shaft at the turbine center. Dental turbines use ball or roller bearings made of ceramic (silicon nitride) or stainless steel, and in high-performance models, air bearings are employed.
- **LED Illumination System:** For improved visibility, some turbines include an LED light source powered by a miniature air-driven generator.

In this problem, the conversion of compressed air energy into mechanical power is analyzed, alongside related phenomena such as torque generation, angular acceleration, rotational kinetic energy, and frictional heating.

2) Problem Statement

In a simplified/idealized mode a dental bur with mass 10 g and radius 0.5 cm is mounted on a turbine and rotates at 350,000 rpm.

- Calculate the angular speed of the bur in radians per second.
- Determine the tip (linear) speed of the bur in meters per second.
- Compute the rotational kinetic energy of the bur. Assume the bur's mass is distributed as a thin disk.
- If the turbine accelerates the bur from rest to 350,000 rpm in 5 seconds, find the average torque required for acceleration.
- Model the mechanical resistance of the tooth surface against the bur as an equivalent pressure $p = F/A$. Assume that the contact area between the bur and the tooth is 1 mm^2 and that the force required for cutting is 2 N. Calculate the resulting pressure on the tooth surface and discuss how changes in cutting force or contact area would affect this pressure.
- Discuss why a high-speed dental turbine requires cooling and safety control, and what physical and biological effects may occur in the case of improper use.

Applied Challenge: Assuming the cutting force remains constant and the same amount of work is required, if the tip speed of the bur is doubled, how will the cutting power and ideal preparation time change?

3) Solution

The questions presented in the previous section are answered below.

a) Angular speed of the bur

$$\omega = \frac{2\pi \times 350,000}{60} \approx 36,652 \text{ rad/s}$$

b) Tip (linear) speed of the bur

$$v = r\omega \approx 0.005 \times 36,652 \approx 183.3 \text{ m/s}$$

c) To determine the kinetic energy, first calculate the moment of inertia:

$$I = 0.5mr^2 = 0.5 \times 0.01 \times (0.005)^2 = 1.25 \times 10^{-7} \text{ kg} \cdot \text{m}^2$$

Then, the rotational kinetic energy is:

$$E_k = \frac{1}{2}I\omega^2 = 0.5 \times 1.25 \times 10^{-7} \times (36,652)^2 \approx 84.0 \text{ J}$$

d) First, determine the angular acceleration:

$$\alpha = \Delta\omega/\Delta t = 36,652/5 \approx 7,330 \text{ rad/s}^2$$

Thus, the required average torque is:

$$\tau = I\alpha = 1.25 \times 10^{-7} \times 7,330 \approx 9.16 \times 10^{-4} \text{ N} \cdot \text{m}$$



e) Pressure on the tooth surface

The pressure on the tooth surface is:

$$p = F/A = 2/(1 \times 10^{-6}) = 2 \times 10^6 \text{ Pa}$$

The contact pressure depends on the cutting force and contact area. An increase in bur speed does not, by itself, necessarily reduce the pressure; the pressure decreases only if the required cutting force decreases or the contact area increases.

f) Cooling and safety control

High rotational speeds and friction generate heat. Without adequate cooling, excessive heat may damage the dental pulp and surrounding tissues and may also affect the bur. Water spray, eye protection, and appropriate control of rotational speed are therefore important safety measures.

Applied Challenge: Assuming the cutting force remains constant, the relation ($P = F \cdot v$) shows that doubling the bur tip speed doubles the cutting power. If the same amount of cutting work is required, the ideal preparation time is therefore reduced by half. Under this assumption, the contact pressure ($p = F/A$) remains unchanged unless the cutting force or contact area changes.

Curriculum Alignment – British Columbia (Sample Mapping)

Physics 12	Circular motion and torque
Physics 11	Work, energy, power, efficiency, and forces
Anatomy and Physiology 12	Tissue organization, organ-system structure and function, and homeostasis
Engineering 12	Applications of dynamics, energy, and mechanical systems in engineering

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The Canine Tooth of the Persian Cheetah

1) Background

The Asiatic cheetah (*Acinonyx jubatus venaticus*) is a Critically Endangered subspecies surviving in Iran, primarily found in plains and semi-desert regions. Like other large felids, the Asiatic cheetah has 30 teeth in total.

The incisors, located at the front of the mouth, are used for scraping flesh from bone. The four canines are long, pointed teeth designed for grasping, holding, and suffocating prey. The premolars and molars have sharp, blade-like surfaces that function like scissors, slicing flesh into smaller pieces to make swallowing easier.

Unlike herbivores, the cheetah lacks flat-surfaced molars for grinding food. Its dental structure is highly specialized for carnivory and efficient meat shearing.

As the fastest land mammal, the cheetah relies heavily on its long and sharp canines for hunting. These teeth are vital for capturing prey, applying strong bite pressure, and tearing tissue.

In this problem, the structure of the cheetah's canine tooth is analyzed from the perspectives of physics and biology.

2) Problem Statement

a) The cheetah's canine tooth can be approximated as a truncated cone with small-base (tip) radius $r = 0.15$ cm, large-base (root) radius $R = 0.6$ cm, and height $h = 2.5$ cm (*This geometry concentrates force at the tip, producing high pressure and better penetration into tissue.*). Calculate the approximate volume of the tooth.

b) For a simplified model, assume the tooth has a uniform effective density of $\rho = 2.6$ g/cm³. Determine the mass of the tooth.

Note: Dental enamel, due to its high mineral content and hydroxyapatite-rich structure, is harder and denser than bone, helping it resist wear during biting.

c) If the bite force of the cheetah is $F = 400$ N, what is the initial pressure exerted by the tooth tip on the prey (*An important carnivore adaptation is a small contact area at the bite point, increasing pressure at the tip.*)?

d) In a longitudinal section, model the canine tooth as a symmetric wedge with apex angle θ . Determine θ and calculate the force normal to the prey's flesh in contact with the tooth surface.

Modeling pressure over time (Optional): If we wish to model how the tooth applies pressure to prey as a function of time, which parameters should be considered, and what would the problem statement and solution outline look like (*To deliver high force in a very short time, the cheetah's jaw requires high neuromuscular coordination.*)?

3) Solution

a) Volume calculation:

$$\frac{\pi}{3}(R^2 + rR + r^2)h = \frac{\pi}{3}(0.6^2 + (0.15 \times 0.6) + 0.15^2) \times 2.5 \approx 1.236 \text{ cm}^3$$

b) Mass of the tooth: $m = \rho V = 2.6 \times 1.236 \approx 3.21 \text{ g}$

c) Pressure exerted on the tooth tip:

$$P = \frac{F}{A} = \frac{400}{\pi(0.15 \times 10^{-2})^2} = 5.66 \times 10^7 \text{ Pa} = 56.6 \text{ MPa}$$

d) Wedge model and normal force: From the figure it is clear that:

$$\tan(0.5\theta) = \frac{R-r}{h} = \frac{0.60-0.15}{2.5} = 0.18$$

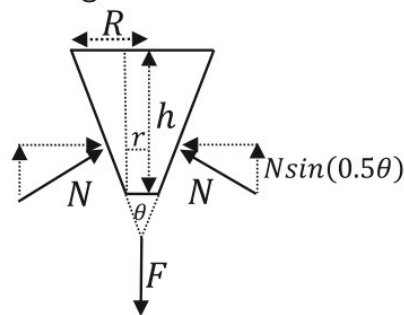
$$\text{Thus: } \frac{\theta}{2} = \tan^{-1}(0.18) \approx 10^\circ \Rightarrow \theta \approx 20^\circ$$

Let N be the tooth-tissue normal force. From the figure we have:

$$F = 2N\sin(0.5\theta).$$

$$\text{Therefore: } N = \frac{F}{2\sin(\frac{\theta}{2})} = \frac{400}{2\sin(10^\circ)} \approx 1150 \text{ N}$$

Note: Since friction is neglected and the tooth edge is not perfectly sharp, the calculations in part (d) should be regarded as approximate.



Curriculum Alignment – British Columbia (Sample Mapping)

Physics 11	Contact forces, normal force, and right-triangle trigonometry
Science 10	Adaptation, natural selection, and extinction
Life Sciences 11	Morphology, adaptation, and evolutionary relationships
Workplace Mathematics 10	Measurement, volume of 3D objects, and unit conversions

References

- [1] IUCN, *The IUCN Red List of Threatened Species*, Version 2022-2, 2022.
- [2] M. S. Farhadinia *et al.*, "The Critically Endangered Asiatic Cheetah *Acinonyx jubatus venaticus* in Iran: A Review of Recent Distribution, and Conservation Status," *Biodiversity and Conservation*, vol. 26, pp. 1027–1046, 2017.
- [3] S. Hillson, *Teeth*, 2nd ed. Cambridge, U.K.: Cambridge University Press, 2005.



Side question: What information is available on the current number of Persian (Asiatic) cheetahs in Iran and their conservation methods? Are you familiar with Delbar, Kooshki, Iran, Firooz, and Pirooz and their fates? How can knowledge of physiology and biological features (e.g., tooth structure) contribute to more effective conservation programs?





The Story of Lily and the Discovery of Self-Confidence

Lily, a 13-year-old girl, enters the psychologist's office with her mother. While the mother begins speaking with the receptionist, Lily curls up on a chair in the corner of the waiting room, avoiding eye contact and quietly scrolling through her phone.

A few minutes later, it is their turn, Lily and her mother step into the psychologist's office together...



Dr. Raven (Psychologist): Lily, dear? Welcome. Come in.

Lily (quietly, turning her face away): Hi.

Lily enters the room, glances around briefly, and sits down on the couch. While speaking, she repeatedly looks away or covers her mouth with her hand.

Dr. Raven: I'm glad you finally came. How are you feeling?

Lily (shrugging): I'm fine. My mom insisted I come.

Dr. Raven: I understand. Sometimes others can see more clearly than we can that we might need a little help. I've noticed that when you talk to me, you cover your mouth with your hands... Would you like to talk about that? Tell me how it feels and why you do it?

Lily (looking down, pausing): I don't know... I just feel like whenever I talk, everyone looks at my mouth. They stare at me, and it feels like they don't even care what I'm saying.

Dr. Raven: I see.

Lily: At school my friends make fun of me because of my braces... They call me "metal mouth" or say things like "aren't you going to turn the lights on?"

Dr. Raven: That must really hurt. Can you tell me more about it?

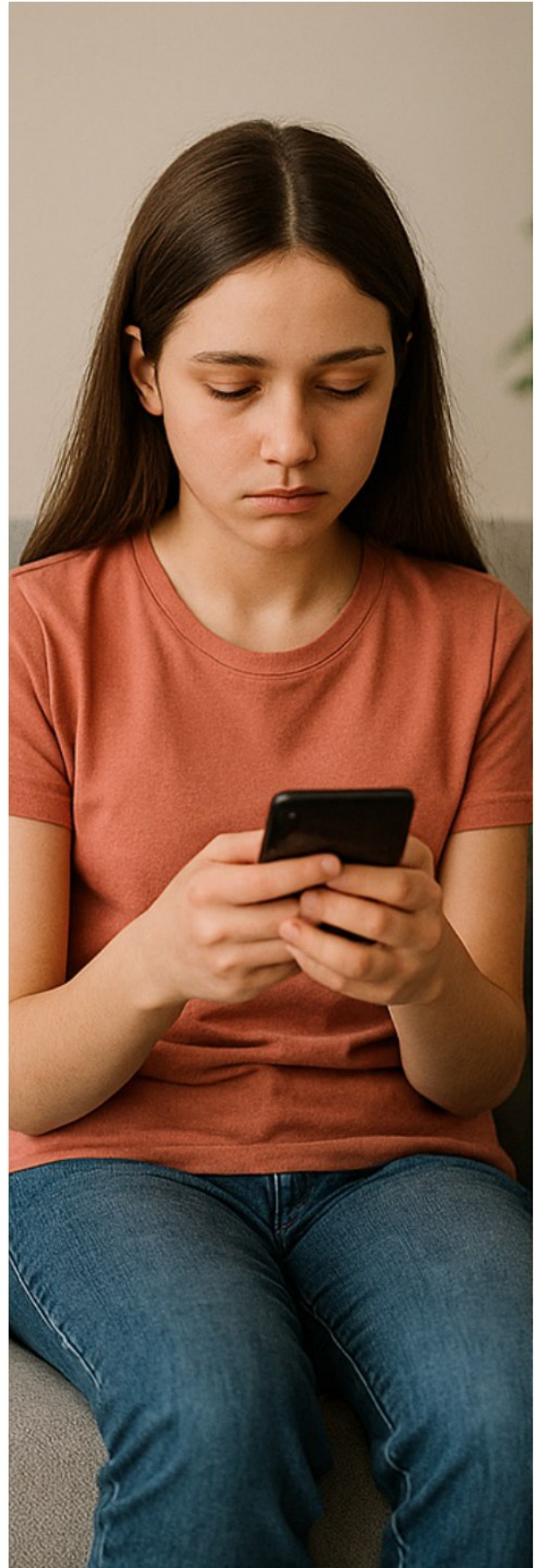
Lily (her voice rising slightly, filled with frustration): Of course it does! It's awful to feel like everyone's staring at you, waiting for you to talk just so they can laugh. I don't even want to speak in class anymore. I always try not to smile. I feel uglier than everyone else. I don't have any confidence. I don't like myself.

Dr. Raven (softly): Lily, let me ask you something... You got braces because you weren't happy with how your teeth looked before, right?

Lily: Yeah, I guess.

Dr. Raven: And you did it because you wanted to make them look nicer, didn't you?

Lily nods silently in agreement.



Dr. Raven: You also know that this treatment takes a certain amount of time, but it's only temporary; those braces won't be there forever, right?

Lily: Yeah, I know that.

Dr. Raven: So, if you already understand that, and you made that choice knowing what it involved, why do you still feel bad about it? Why not focus on the fact that you've made an important decision: a big step toward looking better and feeling more confident. It might sometimes be uncomfortable or even painful, but the hope of a great result gave you the courage to do it.

Lily (after a short silence): Well...yeah, that's true.

Dr. Raven (smiling softly): Now let me ask you something important; what do you think *self-confidence* means?

Lily (glancing around): I don't know...maybe it means liking yourself?

Dr. Raven: That's a good answer. Self-confidence means believing in yourself, in how you look and what you can do, no matter what makes you feel different from others. It means knowing that your value doesn't come from your appearance but from who you are inside, your personality, your kindness, your talents.

Lily: But when everyone only cares about how you look, how can you think that way? What talent do I even have? I'm not as good as everyone else.

Dr. Raven: That's exactly what we need to work on. Your appearance is just one part of you, not all of you. Confidence starts with your *inner voice*. If you keep telling yourself, "I'm not good enough; I'm ugly," you'll believe it. But if you learn to say, "I have value, with all my differences," then little by little, you'll start to see the world differently.

Lily: But how? How can I find that feeling inside me, or make it stronger?

Dr. Raven: There are simple but powerful ways. The first step is recognizing your own abilities...



Those small victories become the building blocks of your confidence. You told me before that you love painting, Lily. That's a wonderful strength! Start with small steps. Finish one drawing and tell yourself, "*I created this. I can do it!*"

Or remind yourself, *“I’m enduring the discomfort of eating with braces because I chose to do something that will make me feel better about myself.”* That means you already have the power to be patient and resilient for a better result. You believe in that outcome.

Lily: But still, whenever I go outside, I get anxious. I’m scared they’ll make fun of me again.

Dr. Raven: You know, Lily, it’s our differences that make us unique. Your teeth might seem like a weakness now, but that’s not what defines who you are. You’re so much more than a smile. You’re an artist, a student, a kind and hardworking girl; those are the things that truly make you *you*.

Lily (smiling a little, this time without hiding her mouth): Actually, when I paint, I feel calm. It’s like I forget anyone could ever laugh at me.

Dr. Raven: That feeling of peace and joy means you’re connecting with your true self. That gives you strength. Over time, you’ll find people who share your interests. You don’t have to change yourself; just find those who appreciate you for who you really are.

Lily: So confidence isn’t just about being more popular?

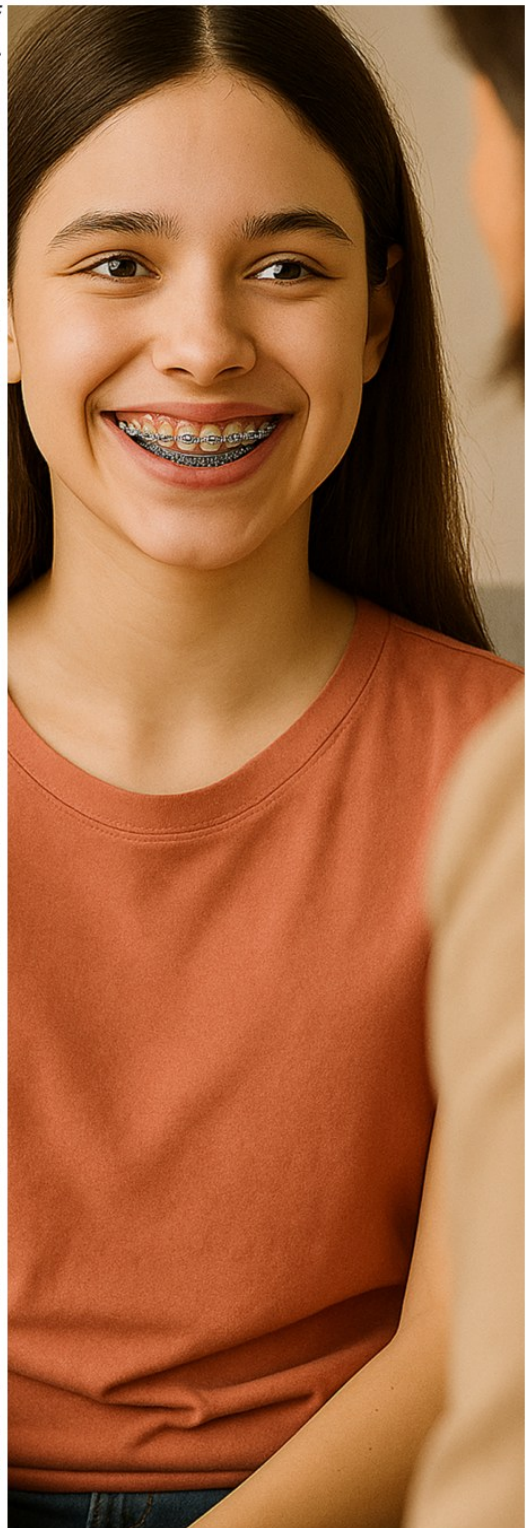
Dr. Raven: No, sweetheart. The real power of confidence is that it lets you shape your life the way you want it. When you believe in yourself, you make choices more easily; you don’t fear people’s opinions or failure. You can set your own goals and go after them.

Lily: I think I get it now. You mean I can be myself and still feel good about it?

Dr. Raven: Exactly! The goal isn’t to become like others; it’s to become the best version of *yourself*. You are worthy, Lily. You just need to start believing it, little by little.

Lily (with more energy, smiling brightly): Thank you, Dr. Raven. I think things are starting to make sense now.

Dr. Raven: I’m glad to hear that. We’ll keep working together in future sessions to strengthen that feeling. Just give yourself time.



Electric Power and Energy in a Comprehensive Dental Clinic

1) Background

As part of an Electricity and Circuits project in Grade 11 Physics, a student examined the electrical equipment of an organization, categorized it, and designed an applied problem from the results.

The chosen setting was a well-equipped dental clinic, whose management cooperated in providing the required data. Based on this information, the clinic's electrical equipment was grouped into five main categories: treatment units and clinical equipment, diagnostic devices, sterilization and laboratory equipment, lighting and general systems, and support/welfare facilities.

Tables 1–5 list the equipment in each category with their power ratings and brief descriptions. Using some of these devices, the student then formulated the applied problem presented in the next section.

Table 1 – Therapeutic

Equipment	Power (W)	Application
Dental unit	400–800	Treatment
Curing light	20–100	Curing
Handpiece	100–300	Cut & polish
Suction	250–500	Suction
Scaler	50–100	Scaling
Compressor	500–1500	Air

Table 2 – Diagnostic

Equipment	Power (W)	Application
Int. X-ray	1000–1500	Imaging
OPG unit	1500–2000	Panoramic
CBCT unit	2000–3000	3D

Table 3 – Laboratory and Sterilization

Equipment	Power (W)	Application
Autoclave	400–800	Tool sterilization
Distiller	20–100	Distilled water
Trimmer	100–300	Model trimming
Vac. pump	250–500	Vacuum

Table 4 – General and Lighting

Equipment	Power (W)	Application
LED lamp	10–20	Lighting
Accent light	20–50	Lobby
HVAC	2000–4000	HVAC
Refrigerator	150–300	Storage
Computer	100–250	Records

Table 5 – Support

Equipment	Power (W)	Application
Television	80–150	TV
Coffee	800–1500	Staff



2) Problem Statement

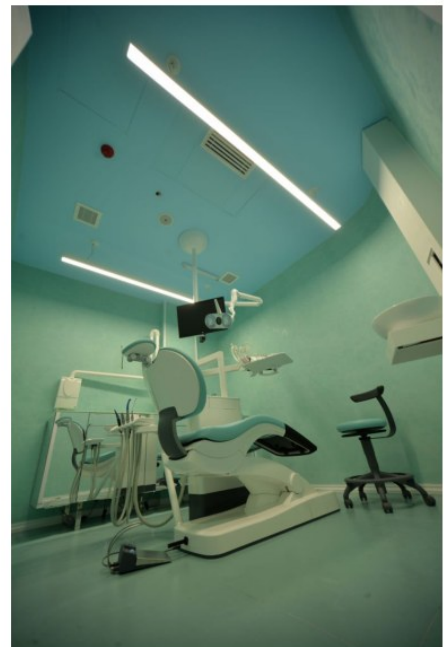
Table 6 shows the average electrical power consumption of the devices and equipment in a dental clinic. The second column gives power consumption in watts, the third column gives the assumed usage pattern, and the fourth column gives the energy consumption in kilowatt-hours. Assume that the clinic serves 150 patients per day.

- What is the upper limit of the total power consumption and the input current to the clinic (the mains voltage is 120 V)?
- Complete the remaining entries in the energy column.
- Calculate the total daily energy consumption of the clinic.

Table 6 – Power and energy consumption of clinic equipment

Equipment	Power	Assumed usage pattern	Energy
10 dental units	500 (120)	40% work (60% standby)	
Air compressor	1500	30% during 8 h	3.600
Central suction	500	40% during 8 h	1.600
30 LED lamps	15	On during all 8 h	3.600
Computer and printer	250	Active during 8 h	2.000
Medical refrigerator	200	40% during 24 h	
HVAC	3000	Active during 8 h	24.000
Intraoral X-ray	1200	30 s for 60% of patients	0.900
OPG	1800	15 s for 10% of patients	0.113
CBCT	2500	10 s for 3% of patients	
Autoclave	2000	2 h per day	4.000
Water distiller	800	1 h per day	0.800
Trimmer / polisher	300	1 h per day	0.300
Vacuum pump	500	1 h per day	0.500
Laboratory microwave	1200	30 min per day	0.600
Micromotor & turbine	200	2 min per patient	1.000
Resin curing light	60	20 s for 80% of patients	0.040

- For this problem, assume the following hypothetical usage-based tariff. The *consumption benchmark* is a predetermined reference level based on typical consumer usage. Assume a benchmark of 400 kWh per month. The base tariff applies when monthly consumption is below the benchmark. If monthly consumption is between the benchmark and 1.5 times the benchmark, each kilowatt-hour is charged at three times the base tariff; between 1.5 and 2.5 times the benchmark, at six times the base tariff; and above 2.5 times the benchmark, at ten times the base tariff. If the base rate is CAD \$0.10 per kWh, what is the clinic's electricity bill for one month?





3) Solution

- a) The upper limit of power consumption is found by summing the values in the second column of Table 6, taking the number of devices in each row into account:

$$P_{\text{peak}} = (10 \times 500) + 1500 + (15 \times 30) + \dots + 200 + 60 = 21\,460 \text{ W}$$

The corresponding peak current is:

$$I_{\text{peak}} = \frac{21460}{120} \approx 178.8 \text{ A}$$

Note: In reality, actual power consumption is lower because not all devices operate simultaneously. They have different load profiles, some systems are shared (e.g., central suction across multiple units), and other practical factors also apply.



b) Average energy consumption of all dental units:

$$(10 \times 500 \times 0.4 \times 8) + (10 \times 120 \times 0.6 \times 8) = 21,760 \text{ Wh} = 21.76 \text{ kWh}$$

Average energy consumption of the medical refrigerator:

$$24 \times 0.40 \times 200 = 1,920 \text{ Wh} = 1.920 \text{ kWh}$$

Average energy consumption of the CBCT unit:

$$10 \times 0.03 \times 150 \times 2,500/3,600 \approx 31 \text{ Wh} = 0.031 \text{ kWh}$$

c) By summing the values in the energy column of Table 6, the clinic's daily energy consumption is obtained. Multiplying this by 30 gives the clinic's average monthly energy consumption. The total daily energy consumption is approximately 66.76 kWh, giving an average monthly consumption of approximately 2,003 kWh.

d) The average consumption is about five times the benchmark (400 kWh). Therefore, the electricity tariff for the clinic is CAD \$1.00 per kilowatt-hour, and the charge for one month of electricity is:

$$1.00 \times 2,003 = \text{CAD } \$2,003.$$

On top of this amount, additional items such as taxes, surcharges, and other applicable fees are added.

A Brief History of Dental Education in Iran

1) Overview

In earlier times, dental care in Iran was empirical, provided by herbalists, barbers, and bathhouse attendants with little scientific knowledge or proper instruments, so patients often faced severe pain and risk. In the late Qajar era, under Nasereddin Shah Qajar, sending students to Europe and the arrival of foreign physicians such as Dr Melczarski, Dr Stump, and Dr Stepanian marked the first steps toward scientific dentistry; the shortage of specialists then led the government to set up a formal training system for *dandansaz* (tooth-makers).

In 1309–1310 SH, a decree by Reza Shah and related legislation led to the founding of the first “School of Dental Prosthetics” (Madrese-ye Dandansazi) in the Dar ul-Funun building, laying the basis for academic dental education. The school trained staff in restoration, denture fabrication, and basic oral care; admission required elementary literacy and good health, and a three-year curriculum combined theoretical and practical medical and technical courses. Graduates who passed the final exam received the title “Official Tooth-Maker of the State”. Its placement under the Ministry of Religious Endowments, Public Instruction and Fine Arts (Vezarat-e Awqaf, Ma’aref va Sanaye’-e Mostazrafeh), rather than the Ministry of Public Health, shows that the technical aspect of dental work still outweighed its medical and public-health role



ل-۶۵

تاریخ ۱۳۱۲ ماه ۱۲

نمره ۱۰۷۴۲۶ ضمیمه

۲۴



وزارت معارف و اوقاف و صنایع مستظرفه

۲

تسمیع در وزارت معارف و اوقاف و صنایع مستظرفه

اداره کل معارف

دایره تعلیمات عالیہ

بنایت در خدمت خاطر مبارک را مستحضر می‌دارد، حسب الامر عالی، اقدام عاجل
کلاس دوازدهم در رشته ریاضی و علم در سال ۱۳۱۲، جاری گردد.

این قسم هم مراتب از طرف مدرسه عالی طب به محصلین مربوطه ابلاغ شد.



سازمان اسناد و کتابخانه ملی
جمهوری اسلامی ایران

بسیار خجسته

وزارت معارف و اوقاف و صنایع مستظرفه

اداره کل معارف

دایره تعلیمات عالیہ

مقام رفیع وزارت جلیله‌ی متبوعه دامت شوکتہ،

با نهایت احترام خاطر مبارک را مستحضر می‌دارد، حسب الامر عالی، اقدام عاجل

راجع به تاسیس کلاس دوازدهم و دندان سازی به عمل آمده و از روز پنجشنبه

۱۷ ماه جاری کلاس مزبور دائر می‌باشد.

همین قسم هم مراتب از طرف مدرسه‌ی عالی طب به محصلین مربوطه ابلاغ شد.

بخط مستقیم
۱۲/۱۲/۱۹

2) Initial Curriculum

In this section, a clean fair copy of the Persian translation of the original three-year curriculum, proposed by Dr Stump as part of an early plan for establishing a dental training school, is presented together with the related illustrations.

حضور مبارک حضرت اشرف انور آقای وزیر معارف دامت شوکته

ترجمه‌ی مراسله‌ی دکتر اشتامپ دندان‌ساز

با کمال افتخار تلواً پیشنهادی راجع به مدرسه‌ی دندان‌سازی تقدیم داشته و توضیحاً خاطر مبارک را در باب اشیاء لازمه که تهیه‌ی آنها نهایت لزوم را دارد، مستحضر می‌دارد. راجع به اشیاء لازمه که میزان تقریبی قیمت آنها را تحقیق فرموده بودید، با کمال تأسف خاطر مبارک را مسبوق می‌نماید به واسطه‌ی نداشتن کاتالوگ فعلاً تعیین آنها غیر مقدور است ولی قبل از قائله‌ی جنگ اروپا، اسباب کار یک نفر محصل با هزار و دویست الی هزار و پانصد فرانک تهیه می‌شد؛ باستثناء کارخانه‌ی مخصوص دندان‌سازی. همچنین برای مدرسه‌ی دندان‌سازی و تعلیم اعمال جراحی و غیره یک نفر مدرس لازم است؛ به‌علاوه، یک مکانیسین به جهت کارخانه‌ی فنی (و تئوری). اصول دروس علمی بالاخص در مدرسه‌ی؟؟ عموماً در مدرسه‌ی طبی پایه تدریس شود. لذا با کمال افتخار حاضر هستم شرفیاب شده و مراتب را حضوراً به‌طور مشروح معروض دارم. احترامات فائقه را تقدیم می‌دارد.

دکتر اشتامپ

ترجمه‌ی مواد پیشنهاد

سال اول

تئوری اصول علمی: تشریح دهان و سر، معرفت‌العظام، جنین‌شناسی، وظائف‌الاعضاء.

مواد فوق‌الذکر باید در مدرسه‌ی دندان‌سازی تدریس شود؛ به‌علاوه سایر دروس طبی که به‌جهت متعلمین طبی دارالفنون نیز تدریس می‌شد (دو ساعت در روز).

اطاق تجربیات: کارهای فنی قالب‌گیری با گچ و سایر مواد مقتضیه از قبیل کائوتشوک یا فلزات بسیطه: ترکیب لحیم، نمونه‌سازی قطعات تشریحی با گچ یا موم، سوهان‌کاری و غیره، عمل دندان کشیدن (پنج ساعت در روز)

سال دوم (دندان‌ساز متخصص-تئوری اصول علمی): تشریح، معرفت‌العظام، معرفت‌النسوج، معرفت‌الجراثیم میکروب‌شناسی، خراش و فقدان مینای دندان، تراش دندان، معرفت‌الامراض راجع به دندان‌سازی (قسمت بزرگ عصب داخل دندان)، جراحات و سایر امراض عصب داخلی دندان (جای دندان)، (ورم ضریع غشاء سطحی استخوان‌های لانه‌ی زنبوری جای دندان)، امراض غشاء مخاطی عموماً معرفت‌الامراض، (رتین ایکس شعاع) (دو الی سه ساعت در روز)

اطاق تجربیات اعمال فنی: مفصل‌تر از دوره‌ی سال اول و مخصوصاً راجع به اصلاح و تنظیم دندان‌های غیر منظم و فلزکاری (چهار الی پنج ساعت در روز)

رحمہ مراد دکت شمس و زمانہ ز

بالحال اشقر و قرآ شنبه دی راجع بهر دهن زنی تقدم داشته و در قیام خاطر با کبریا در باب هشتم دانسته که همه آنها
نهایت لذت و داد و دهده مختصر میراند راجع به شش دانسته که میزان تقریر قریه آنها را محقق فرماید و بهر حال که
خاطر را که اسبق منم و باطله نه اشقی که اگر نقدی آنها غیر معتقد است و که قهر از ناکه جنگ در باب هشتم
کار کثیر مختصر به هزار روایت از هزار و پانصد فراموش شده است و بهر حال که در این مختصر در این باب
همین مختصر دهن زنی و قیام اعمال حرامی و غیره یک نفر بیشتر ندانم است بعد از یک نفر که این
تجه لارخانه فقی (دوره دوی) بهر حال که در این مختصر در این باب و در حقیقت بهر حال که در این
نزد بالحال اشقر و قرآ شنبه دی راجع بهر دهن زنی تقدم داشته و در قیام خاطر با کبریا در باب هشتم دانسته که همه آنها
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رحمہ اللہ و شہاد

سال اول

(سازنده اصول علی) تسبیح دهان در سوره ایلیم جنین شناس و طایف اعضا و متوافق الکلی چه در حدسه و نهانی در ترمیم و در حدسه طبعیه که بجهت تسکین قبح دارد و بعد از زهر مرمر میزد (و بیست و سه روز)

اطلاق تحریرات

لاری قنی کاب سرکه، کج دیا رتله شفته ذقیر لاورند باقرات بطم: ترکیب نیم
نونه سانی قطعات تشریحی باکچ یا نموم ردان لای وغیره عمر دوزان کشیدن
(پنج ساعت در روز)

ص ۴۴ (زینب: مختصر)

(تہ دوری اصول علمی)

شرح موفه لطیف موفه بنسج (موفه بچاشم) مکرر شناسی (حاضر دفعان فی دزدان
تأثر دزدان موفه الدردن راجع به دزدان (قسمت بزرگ عصب دافع دزدان) جواهر دبیاری
عصب دافع دزدان (جوی دزدان) (دوم ضریف اف و سطحی آهناهای دانه زنده دزدان)
اراضی اف و سطحی عمر موفه الدردن دزدان (اینی دیگر شاع به)
(هـ الحقه تحت دزدان)

(۱۵۲۵)

حال فخر مصدق در دوره سال اول و دوم راجع به مصحح و تنظیم و راهنمای غیر مصنف و نقل کاری

الحق محرمات

(چہار الے پنج عبت در روز)

قسمت عملی: کشیدن دندان و اعمال ساده‌ی دهان

سال سوم (تئوری اصول علمی): مراجعه‌ی دروس سنوات قبل به‌علاوه‌ی مواد دروس طبیه، طرز نسخه‌نویسی، امراض دندان و عوارض آن، انتقال دندان طبیعی از دهانی به دهان دیگر (یک ساعت در روز)

قسمت فنی: کلیه‌ی کارهای مربوط به اطاق تجربیات

قسمت عملی: کلیه‌ی عملیات در دهان به‌وسیله‌ی مرضاء

3) Questions

This section poses a few questions based on the previous material. Answering them will highlight important historical and scientific points.

- a) When did the royal court first gain access to a tooth-maker (dentist), and when did such access become available to the general public?
- b) Why, at the beginning of its activity, was the School of Dental Prosthetics a subdivision of the Ministry of Education (Ma'aref)?
- c) When did Dr. Stump come to Iran? What historical events took place during his stay, how did they affect his time in Iran, and in which Iranian novel is he mentioned?
- d) When was the idea of transplanting a tooth from one person to another first discussed? Is there a scientific basis for this practice? What results were reported in the past, and what is the current scientific view?
- e) In present-day Persian medical terminology, what are the equivalents of expressions such as:

"معرفت‌العظام"، "معرفت‌النسوج"، "معرفت‌الجراثیم"، "معرفت‌الامراض"، "ورم ضریع غشاء سطحی استخوان‌های لانه‌ی زنبوری جای دندان"، "رتین ایکس شعاع".

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۲۹۷-۳۴۸۴۱

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قسمت مع کشیدن دندان در حال ساده دندان

سال ۱۳۰۴ (در اصل ۱۳۰۳) مراجعه دندرس سوزات قبر بعد از مرگ دندرس طایفه
انتقال دندان طبع دندان برکان دیگر
(یک عادت در روز)

قسمت فخر کلمه لاری مربوط باطن تجویزات

قسمت مع کلمه عقیق دندان برسیه رفا



Teledentistry and the International Space Station

1) Background

Teledentistry refers to the use of telehealth systems and methods in dentistry to support the delivery of dental care through digital communication, including the exchange of data and images, as well as live communication.

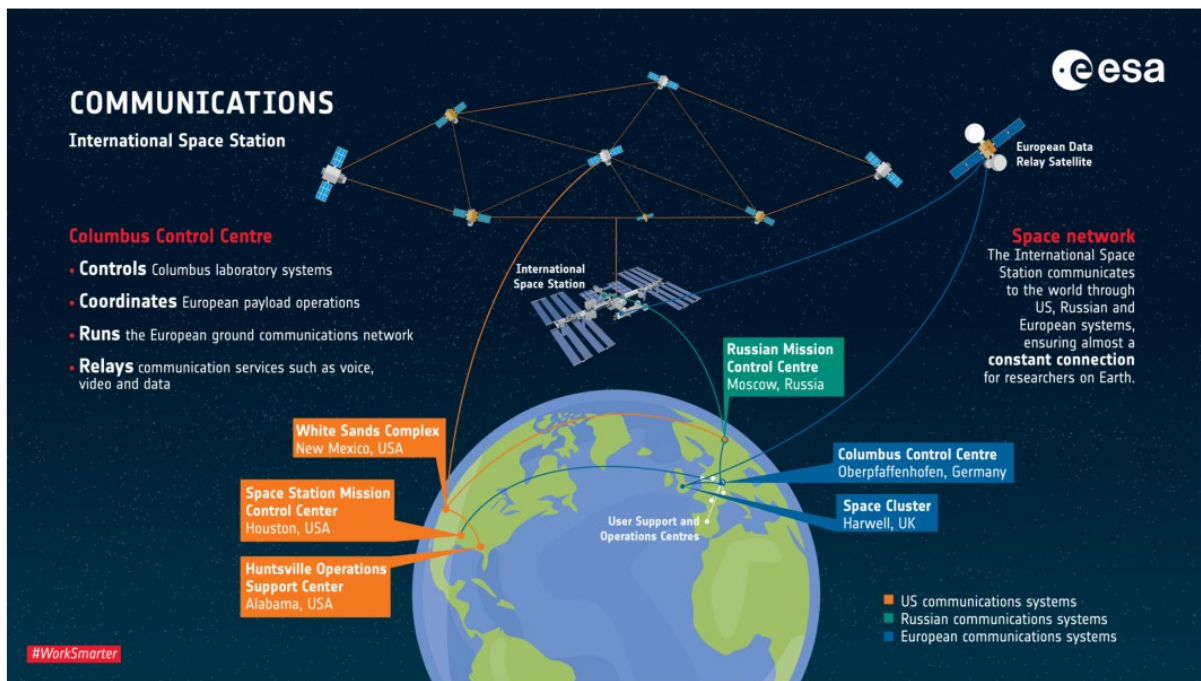
Teledentistry is especially relevant to remote and underserved settings, including rural communities and military environments, while related telemedicine approaches are also used in extreme environments such as Antarctica and space missions.

Teledentistry is delivered in several forms, including:

- synchronous communication in the form of live videoconferencing between the dentist and the patient,
- store-and-forward transmission of radiographs or oral scans for non-real-time assessment,
- remote monitoring using sensors and smart devices to track oral health.



NASA astronaut Charles "Pete" Conrad, commander of the Skylab 2 mission, is receiving a dental examination from medical officer Joseph Kerwin in the medical section of the Skylab station (NASA, 1973).



Using NASA and European relay and ground networks, the space station sends medical and scientific data to Earth, supporting telemedicine and other remote medical communication in space.

2) Problem Statement

International Space Station (ISS) missions do not typically include a dentist on board. Astronauts receive basic training, but in the event of dental pain or injury they must be guided from Earth. The National Aeronautics and Space Administration (NASA) uses a satellite network called the Tracking and Data Relay Satellite System (TDRSS) for this purpose. The TDRSS includes a constellation of Tracking and Data Relay Satellites (TDRS) in geosynchronous orbit, roughly 35,786 km above Earth, which provide broad relay coverage between spacecraft and ground facilities.

The signal from the ISS is transmitted to a TDRS satellite in view, which relays the data to NASA's ground antennas at the White Sands Complex in New Mexico. From there, the data are carried over terrestrial networks to the Johnson Space Center in Houston, where a dentist on Earth can view live images and sensor data.

During a space station mission, an astronaut with pulpitis is to be treated remotely under the guidance of a dentist on Earth.

The technical details of the communication system are as follows:

- Approximate ISS altitude above Earth: 400 km (context only; not used in the simplified delay calculation)
- Assumed distance from the ISS to a TDRS satellite: 35,786 km
- Assumed distance from the TDRS satellite to the White Sands Complex in New Mexico: 35,786 km
- Distance from White Sands, New Mexico, to the Johnson Space Center in Houston: 1,200 km
- Propagation speed of electromagnetic signals in space (vacuum): 3×10^8 m/s
- Propagation speed of waves in optical fiber: 2×10^8 m/s
- Medical communication bandwidth: 50 Mbps
- Data rate for live video and sensor signals: 4 MB/s

Using the given information, answer the following:

a) What are the one-way and round-trip time delays along the simplified ISS–TDRS–White Sands–Houston path (with the White Sands–Houston link modeled as optical fiber)? Is this delay acceptable for real-time guidance of a dental procedure?

An astronaut is practicing tooth extraction on a model. Dental emergencies are among the main factors that can negatively affect long-duration missions.



- b)** Is a bandwidth of 50 Mbps sufficient to transmit HD images and biosignals continuously without interruption?
- c)** If the connection is lost for a few seconds, what safety mechanism should be built into the system?
- d)** For interplanetary missions such as Mars, with an average distance of 225 million kilometres, what would the communication delay be, and is live treatment still possible?
- e)** How does microgravity redistribute body fluids, and what additional precautions might be needed during dental procedures involving gingival bleeding, local anaesthesia, fluids, and debris?
- f)** Why does the ISS rely on TDRS relay satellites for near-continuous communication with Earth instead of communicating only through direct links to ground stations?

3) Solution

a) For the simplified model, the one-way space-link delay from the ISS to a TDRS satellite and then to White Sands is:

$$\Delta t = \frac{71,572,000}{3 \times 10^8} \approx 0.239 \text{ s}$$

The one-way communication delay between White Sands, New Mexico, and the Johnson Space Center in Houston is:

$$\Delta t = \frac{1,200,000}{2 \times 10^8} \approx 0.006 \text{ s}$$



The Airbus A310 Zero-G research aircraft is used by the European Space Agency to generate short periods of weightlessness (microgravity). During one of its parabolic flights, a research team from the SpaceDent project conducted dental experiments in simulated weightless conditions.

The 0.006 s terrestrial delay is small compared with the approximately 0.239 s space-link delay.

The total one-way delay is approximately 0.245 s, and the round-trip delay is approximately 0.49 s. The delay would be noticeable in conversation, but real-time consultation and video guidance would still be feasible.

b) A bandwidth of 50 Mbps is equivalent to $(50 \text{ Mbps})/8 = 6.25 \text{ MB/s}$. In this simplified model, a 4 MB/s data stream can be accommodated within a 50 Mbps connection.

c) If the communication link is lost, the procedure should enter a safe-stop state. The local crew member should pause treatment, secure the instruments, and follow a preplanned emergency protocol until communication is restored.

d) The one-way delay for communication with Mars is:

$$\Delta t = \frac{2.25 \times 10^{11}}{3 \times 10^8} = 750 \text{ s}$$

This delay is equal to twelve and a half minutes, so the round-trip delay is twenty-five minutes. In this situation, real-time guidance is impossible. Dental care would require greater crew autonomy, preplanned procedures, and potentially future semi-autonomous treatment systems.

e) Microgravity causes a headward redistribution of blood and tissue fluid, which can produce facial puffiness and alter fluid handling in the oral region. Evidence is currently insufficient to define a specific change in gingival bleeding or local-anaesthetic dosage. Dental procedures in microgravity therefore require careful stabilization, fluid and debris containment, suction, and close monitoring.

f) Because the ISS moves rapidly in low Earth orbit, a direct link to a single ground station would frequently be lost as the station moved below the horizon. TDRS satellites in geosynchronous orbit provide broad line-of-sight coverage and relay signals to a small number of ground facilities, enabling near-continuous communication.

Topical Alignment with British Columbia High School Courses

Physics 11	Wave propagation, wave speed, and time-delay calculations
Physics 12	Uniform circular motion, orbital motion, and gravitational fields
Computer Studies 10	Wired and wireless networking and digital communication
Anatomy and Physiology 12	Organ systems, homeostasis, and physiological responses to changing conditions

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Although teledentistry systems are already used on Earth in a variety of applications, deploying such systems in space involves three major challenges:

- 1. long communication delays,**
- 2. structural modifications to ensure proper performance in microgravity,**
- 3. the need to train astronauts to operate this type of equipment.**

The main challenge is likely to be the communication delay over very long distances, such as between Earth and Mars. For this reason, implementing teledentistry in space in its full clinical sense remains an active area of research.

**“As you cleanse your teeth, cleanse your words as well;
let no ill speech of others stain your mouth.”**

Translated from a verse by Saib Tabrizi, a 17th-century Persian poet from Iran.

The CCK CLERESTORY is an interdisciplinary educational and scientific journal dedicated to curriculum-aligned teaching and learning. Each issue explores a central theme through problems and educational content drawn from mathematics, physics, chemistry, history, and other disciplines. Developed with guidance from subject-matter experts, the journal connects school-based knowledge with real-world contexts and encourages meaningful links across disciplines. Its aim is to strengthen students' motivation, deepen conceptual understanding, and foster curiosity and critical thinking.