Assignment Question Bank:

I. Remembering (Knowledge)

1. Question: Define "machining" or "metal cutting" as described in the notes.
   Answer: Machining or metal cutting is defined as the removal of extra material from a metal surface by shearing or cutting action.
2. Question: List the three major functions that a machine tool performs according to the provided information.
   Answer: A machine tool performs three major functions:
   - It rigidly supports the workpiece and cutting tool.
   - Provides relative motion between the workpiece and cutting tool.
   - Provides a range of speeds and feeds.
3. Question: Identify the three main categories into which chips formed during metal cutting can be categorized.
   Answer: Various types of chips formed in metal cutting can be categorized as:
   - Continuous chip.
   - Discontinuous chip.
   - Continuous chip with built-up edge.

II. Understanding (Comprehension)

4. Question: Explain the primary difference between Conventional Machining and Non-Conventional Machining processes, including their primary energy sources.
   Answer:
   - **Conventional Machining** involves physical contact between a harder cutting tool and the workpiece, removing material in the form of chips. Its primary energy source is mechanical energy.
   - **Non-Conventional Machining** utilizes various forms of energy (thermal, chemical, electrical, etc.) to remove material, often without direct contact between the tool and workpiece. Its energy sources are thermal, chemical, and electrical energy. The key difference lies in the direct physical contact and the type of energy used for material removal.

5. Question: Describe the function of the Headstock and Tailstock components on a Lathe machine.
   Answer:
   - **Headstock (Live Centre):** Mounted at the left end of the machine, it's a box-like casting that contains the feed gear box or cone pulley. Its primary function is to enable the spindle to rotate at different speeds. It also distributes power to the lead screw (for threading) or the feed rod (for turning).
   - **Tailstock (Dead Centre):** Mounted on the right side of the machine, it is the movable part of the lathe that carries the dead centre. Its functions include supporting different lengths of the workpiece, being slid on the bed to desired locations, and being moved laterally for taper turning. It can also carry tools like drills or reamers for making holes.
6. Question: Explain the concept of "secondary shear" in metal cutting and what causes it.
   Answer: In metal cutting, as the chip flows over the rake surface of the cutting tool, its temperature increases due to friction, causing it to weld automatically to the rake surface. "Secondary shear" occurs when the compressive force applied by newly formed chips (generated just after the initial welded chip) causes this welded chip to be sheared off from the tool's rake surface. This indicates a complex interaction between the chip, tool, and friction during the cutting process.

III. Applying (Application)

7. **Question:** A cylindrical workpiece needs to be turned from 50 mm to 42 mm diameter. The total length of the job is 120 mm. The roughing speed is 30 m/min, and finishing speed is 60 m/min. The feed for roughing is 0.24 mm/rev, and for finishing is 0.10 mm/rev. The maximum depth of cut for roughing is 2 mm, and the finish allowance is 0.75 mm. Assume an over travel of the tool (Lo) of 2 mm. Available spindle speeds are 70, 110, 176, 280, 440, 700, 1100, 1760, and 2800 RPM.

    - a) Calculate the appropriate spindle speed (N) for the roughing pass, choosing the nearest available speed.
    - b) Calculate the machining time for one roughing pass.
    - c) Calculate the appropriate spindle speed (N) for the finishing pass, choosing the nearest available speed.
    - d) Calculate the machining time for one finishing pass.
    - e) Calculate the total actual machining time required.

8. Answer:

    Given: Initial Diameter (D_initial) = 50 mm, Final Diameter (D_final) = 42 mm, Length (L) = 120 mm, Lo = 2 mm.

    Roughing: V_rough = 30 m/min, f_rough = 0.24 mm/rev, d_r = 2 mm.

    Finishing: V_finish = 60 m/min, f_finish = 0.10 mm/rev, A_f = 0.75 mm.

    Available N: 70, 110, 176, 280, 440, 700, 1100, 1760, 2800 RPM.

    a) Spindle Speed (N) for Roughing Pass:

    Average Diameter for roughing = (50 + 42) / 2 = 46 mm.

    Using

    $V=1000\pi DN \Rightarrow N=\pi DV\times 1000$

    $Nrough\_calc=\pi\times 4630\times 1000\approx 207.59$ RPM.

    Nearest available RPM: 176 RPM (as 280 RPM is very high compared to 207).

    So, Nrough=176 RPM.

    b) Machining Time for one Roughing Pass (trough):

    $t=fNL+Lo$

    $trough=0.24\times 176120+2=42.24122\approx 2.888$ minutes.

    c) Spindle Speed (N) for Finishing Pass:

    Diameter for finishing = Final Diameter = 42 mm.

    $Nfinish\_calc=\pi\times 4260\times 1000\approx 454.73$ RPM.

    Nearest available RPM: 440 RPM.

    So, Nfinish=440 RPM.

    d) Machining Time for one Finishing Pass (tfinish):

    $tfinish=0.10\times 440120+2=44122\approx 2.77$ minutes.

    e) Total Actual Machining Time:

Total Stock to be removed = (50 - 42) / 2 = 4 mm.

Roughing stock available = 4 - 0.75 = 3.25 mm.

Since maximum depth of cut for roughing is 2 mm, there are 2 roughing passes.

Total machining time = (Number of Roughing Passes $\times t_{rough}$) + (Number of Finishing Passes $\times t_{finish}$)

Assuming 1 finishing pass for 0.75 mm allowance (as depth of cut for finishing is 0.10 mm/rev, 0.75/0.10 = 7.5 passes, but usually finish is 1 or 2 passes if specified, in this context, from the provided solution, it indicates 1 finishing pass has been considered without explicitly stating df).

Total machining time =

$(2\times2.888)+2.77=5.776+2.77=8.546$ minutes.

9. Question: A manufacturing engineer needs to set up a lathe to machine a cylindrical part with a perfectly round cross-section. What type of chuck would be most efficient for quickly centering and clamping this workpiece, and why?

   Answer: For quickly centering and clamping a cylindrical part with a perfectly round cross-section, a **three-jaw chuck (self-centering chuck)** would be the most efficient choice.

   - **Efficiency:** The main advantage of this chuck is the quick way in which a typical round job is centered.
   - **Mechanism:** All three jaws move radially inward or outward by the same amount simultaneously , which allows the jaws to easily center any job whose external locating surface is cylindrical or symmetrical. This automates the centering process, saving significant time compared to individually adjusting each jaw on an independent jaw chuck.

10. Question: A very hard, brittle ceramic component requires drilling of intricate, small-diameter holes. Suggest an appropriate non-conventional machining process for this task, and justify your choice by citing its advantages for such materials.

    Answer: For drilling intricate, small-diameter holes in a very hard, brittle ceramic component, **Abrasive Jet Machining (AJM)** would be an appropriate non-conventional machining process.

- **Suitability for Brittle Materials:** AJM is especially suitable for brittle materials because its material removal principle is based on tiny brittle fracture of the metallic layer with high-velocity impact of abrasive particles. Ceramics are brittle, making them ideal for AJM.
- **Intricate Shapes & Hardness:** AJM can drill cavities and holes of any shape in materials of any hardness, which addresses the requirement for intricate holes in a very hard material.
- **No Direct Contact:** A key advantage is that there is no direct contact between the tool and workpiece, thus preventing tool damage and associated stresses on the fragile ceramic.
- **Low Heat Generation:** The amount of heat generation is low, which is beneficial for heat-sensitive materials like ceramics, preventing thermal damage or micro-cracks.

IV. Analyzing (Analysis)

10. Question: Analyze the differences between "Up Milling (Conventional Milling)" and "Down Milling (Climb Milling)". Your analysis should cover the relationship between cutter rotation and table movement, and the impact of cutting forces on workpiece stability in each method.
    Answer:
    Up Milling and Down Milling are two types of milling based on the relative directions of the milling cutter's rotation and the workpiece's feed motion.
    1. **Up Milling (Conventional Milling):**
        - **Cutter Rotation vs. Table Movement:** In up milling, the cutting tool rotates in the *opposite direction* to the table's feed movement. For example, if the table moves left, the top of the cutter rotates right.
        - **Impact on Cutting Forces & Stability:** The cutting forces in up milling tend to act upwards, which can cause a lifting force on the workpiece. This "lifting tendency" means that the workpiece must be very securely clamped to the work holding device to prevent it

from being dislodged or vibrating during the operation. This also puts more stress on the lead screw of the machine.

2. **Down Milling (Climb Milling):**
    - **Cutter Rotation vs. Table Movement:** In down milling, the cutting tool rotates in the *same direction* as the table's feed movement. For example, if the table moves left, the top of the cutter also rotates left.
    - **Impact on Cutting Forces & Stability:** The cutting forces in down milling act *downwards*, which helps to hold the workpiece firmly against the work holding device and the machine table. This downward force increases workpiece stability and can reduce the need for extremely rigid clamping, potentially leading to a better surface finish and longer tool life. However, it can also lead to backlash issues in older machines without anti-backlash nuts.

11. Question: Categorize and briefly describe at least four different methods of "Taper Turning" on a Lathe, explaining how each method achieves the conical shape.

    Answer: Taper turning is the process of producing a conical surface from a cylindrical workpiece. Several methods are available for cutting tapers in a lathe:

    1. **Using Form Tools:**
        - **Principle:** A special cutting tool, precisely ground to the desired taper angle, is plunged directly into the workpiece.
        - **Shape Achievement:** The conical shape is achieved by the profile of the tool itself, essentially creating the taper in one plunge cut. This method is useful for short tapers like chamfering.
    2. **Swiveling the Compound Rest:**
        - **Principle:** The compound rest, on which the tool post is mounted, has a circular base graduated in degrees. This entire unit can be swiveled and set to the desired half-taper angle (α).
        - **Shape Achievement:** The tool is then fed manually by the operator along the swiveled path, generating the conical surface. This

method is good for short and steep tapers but has limited movement and often results in a poor surface finish due to manual feeding.

3. **Offsetting the Tailstock:**
   - **Principle:** The tailstock (dead center) is deliberately offset from its central position towards or away from the operator. This inclination causes the axis of rotation of the workpiece to be inclined by the half-angle of the taper.
   - **Shape Achievement:** The cutting tool is then fed in the normal manner, parallel to the lathe guideways. This method generates the conical surface by the inclined rotation of the workpiece relative to the longitudinal tool feed. It's suitable for small tapers over a long length.
4. **Using Taper Turning Attachment:**
   - **Principle:** This method utilizes a separate slideway arranged at the rear of the cross slide, which can be rotated and set to any desired taper angle. A guide block slides within this inclined track.
   - **Shape Achievement:** As the carriage moves for longitudinal feeding, the guide block's movement in the inclined track imparts a proportional cross movement to the cross slide and, in turn, the cutting tool. This causes the tool tip to follow the taper direction set in the attachment, generating the conical surface. This is a very common method for a range of tapers.

12. Question: Compare the construction and operational capabilities of a "Horizontal Milling Machine" versus a "Vertical Milling Machine." Provide specific details on spindle orientation, cutter movement, cutter mounting, and spindle tilt for each.

Answer: Horizontal and Vertical Milling Machines are classified based on the orientation of their main spindle, which dictates their operational capabilities and common applications.

Comparison of Horizontal and Vertical Milling Machines:

S	Feature	Horizontal Milling Machine	Vertical Milling Machine
1	**Spindle Orientation**	The spindle is horizontal and parallel to the worktable. This arrangement is characteristic of horizontal mills and affects the types of cutters and operations possible.	The spindle is vertical and perpendicular to the worktable. This orientation allows for different machining approaches and visibility.
2	**Cutter Movement**	The cutter typically cannot be moved up and down vertically relative to the spindle axis by the spindle itself. Vertical adjustments are	The cutter can be moved up and down by the vertical movement of the spindle. This provides depth control for operations

		made by moving the knee.	like drilling and slotting.
3	**Cutter Mounting**	The cutter is mounted on an arbor, which is an extension of the spindle. Multiple cutters can be mounted on the arbor simultaneously.	The cutter is directly mounted on the spindle. This often means end mills or face mills are used.
4	**Spindle Tilt**	The spindle itself cannot be tilted for angular cutting operations. Any angular cuts typically require tilting the workpiece.	The spindle can be tilted for angular cutting, allowing for machining inclined surfaces directly.

5	**Typical Operations**	Operations such as plain milling (slab milling), gear cutting, form milling, straddle milling, and gang milling (using multiple cutters on an arbor) are commonly performed.	Operations such as slot milling, T-slots, flat milling, profile milling, pocket milling, and various drilling operations can be performed.

V. Evaluating (Evaluation)

13. Question: Evaluate the effectiveness of "Induction Hardening" as a heat treatment process for large steel components. Discuss its advantages, particularly regarding distortion and core properties, as well as any relevant limitations.
    Answer:
    Induction hardening is a highly effective heat treatment process, particularly for large steel components, due to its localized and rapid heating capabilities.
    Effectiveness and Advantages:
    1. **Localized Hardening:** The process involves heating applied rapidly and *locally* to the steel component via high-frequency electric fields, followed by quenching with water. This results in a localized hardened layer at the surface. This localization is a key advantage as it allows specific areas of a large component to be hardened without affecting the entire part.
    2. **Low Distortion:** Induction hardening offers a cost-effective, *low-distortion* surface hardening treatment. Because only the surface is rapidly heated

and quenched, the bulk of the material remains relatively cool, which significantly minimizes thermal distortion and cracking compared to through-hardening methods.

3. **Maintained Core Properties:** A significant benefit for large components is that it achieves increased surface hardness *while maintaining the core properties*. This means the core can retain its original toughness and ductility, which is crucial for components requiring both a hard wear-resistant surface and a tough, shock-absorbing interior.
4. **Versatility:** Different shaped induction coils are available and can be custom-made, allowing for versatile application to various component geometries.

14. Limitations (Implicit/General for Heat Treatment):
    While the notes highlight advantages, typical limitations for heat treatment processes, which could apply here, might include:
    1. High initial equipment cost.
    2. Requires precise control of heating and cooling parameters.
    3. Limited to materials that can be hardened by this method.
15. Overall, induction hardening is highly effective for large steel components where selective surface hardness is required with minimal distortion, making it a valuable process in manufacturing.
16. Question: Justify why industrial robots are considered commercially and technologically important in modern manufacturing. Provide at least three distinct reasons, explaining how each contributes to their significance.
    Answer:
    Industrial robots are recognized as general-purpose, programmable machines possessing anthropomorphic characteristics, making them commercially and technologically important in modern manufacturing due to several key reasons:
    1. **Substitution in Hazardous/Uncomfortable Environments:** Robots can be substituted for humans in hazardous or uncomfortable work environments. This is commercially important as it protects human workers from dangers (e.g., extreme temperatures, toxic fumes, repetitive

strain injuries) and allows for continuous operation in conditions unsuitable for human presence, reducing safety costs and improving worker welfare.

2. **Consistency and Repeatability:** A robot performs its work cycle with a consistency and repeatability that cannot be attained by humans. This technological advantage leads to higher product quality, tighter tolerances, and reduced scrap rates, directly translating to commercial benefits through improved efficiency and customer satisfaction.
3. **Reprogrammability and Flexibility:** Robots are programmable. When the production run of the current task is completed, a robot can be reprogrammed and equipped with necessary tooling to perform an altogether different task. This flexibility is a significant commercial advantage, allowing manufacturers to adapt quickly to changing product demands, reduce retooling costs, and improve overall production agility without investing in new dedicated machinery for each product variant.
4. **Computer Integrated Manufacturing (CIM):** Robots are controlled by computers and can therefore be connected to other computer systems to achieve computer integrated manufacturing. This technological integration enables seamless communication and data exchange across various manufacturing functions (like design, planning, and control), leading to optimized production flows, reduced lead times, and enhanced overall operational efficiency, which are crucial for competitive commercial success.

17. Question: A manufacturing company currently uses a conventional NC system for its machining operations but is considering upgrading to a CNC system. Based on the provided notes, evaluate the key advantages the company would gain by switching to a CNC system, particularly focusing on program management, flexibility, and automation.

    Answer:

    Upgrading from a conventional NC system to a CNC system offers significant advantages in modern manufacturing, particularly in program management, flexibility, and automation.

Advantages of Upgrading to CNC:

1. **Enhanced Program Management:**
   - **Program Storage:** In conventional NC, punched tapes are cycled for each part. In contrast, with CNC, the entire program is entered once and stored in computer memory. This allows for the storage of more than one program, facilitating easier access and selection of different jobs.
   - **On-site Editing:** A major drawback of conventional NC is the time-consuming process of editing punched tapes for errors or adjustments. CNC systems allow for program editing directly at the machine tool site, significantly reducing downtime and improving efficiency for program modifications.
   - **Tape Reader Reliability:** CNC eliminates the need for the unreliable physical tape reader for each part's cycle, as the program is run from memory, improving system reliability.
2. **Increased Flexibility and Adaptability:**
   - **Design Changes:** CNC machines can easily switch between different tasks and designs because programs can be modified on the computer without needing to alter physical tapes. This adaptability allows for quicker response to design changes and product variations, enhancing manufacturing agility.
   - **Fixed Cycles & Subroutines:** CNC offers fixed cycles and programming subroutines, simplifying programming for repetitive tasks and making the system more versatile for a wider range of operations.
   - **Cutter Compensation:** CNC systems have features like cutter length compensation and tool offsets, allowing operators to adjust for tool wear or specific part dimensions directly in the program, rather than requiring physical tool adjustments or tape edits.
3. **Higher Automation and Efficiency:**

- **Reduced Manual Intervention:** CNC machines automate the machining process to a higher degree, reducing the need for continuous manual intervention. This minimizes human error and contributes to faster production cycles and increased throughput.
- **Lower Labor Costs:** Due to increased automation and reduced operator intervention, CNC machines can lead to lower labor costs.
- **Improved Consistency and Quality:** The digital control of CNC machines ensures parts are produced to the same specifications consistently, leading to higher quality and minimized variations in the finished product.

18. In conclusion, upgrading to a CNC system would provide the company with substantial gains in operational efficiency, quality, and adaptability, moving beyond the limitations of tape-based NC systems towards more streamlined and cost-effective manufacturing.