

Outdoor Power Equipment Technician

Study Guide



Recreational Power Equipment

Final Period And Qualification Exam

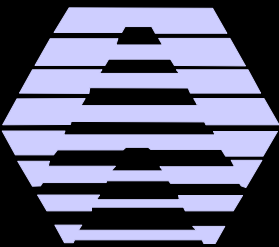


Table of Contents

Block Diagrams	1
General (from periods 1, 2, 3).....	1
Fuel Systems	3
Practice Questions for Fuel Systems.....	4
Engine Overhaul	5
Practice Questions for Engine Overhaul	6
Accessories	7
Practice Questions for Accessories	8
Ignitions	9
Electronics.....	10
Practice Questions for Ignitions and Electronics	11
Clutches and Transmission	12
Practice Questions for Clutches and Transmission.....	13
Steering and Suspensions.....	14
Practice Questions for Steering and Suspensions	15
References.....	16

Block Diagrams

Fuel Systems

<i>Fuel Supply</i>	Tanks/vents/pickups	Fuel Pumps Auto Shutoff	Primers
	Oil Injection Set up & bleeding		
<i>Carburetors</i>	Round & Flat Slide	Jets & Circuits	Constant Velocity
<i>Carburetor Adjustments</i>	Idle Stops	Throttle Cable Sync.	Effects of Maladjustment
<i>Jetting Principles</i>	Plug Reading	Piston Wash	Pyrometer Location
	Pyrometer Readings	Dial A Jet / Power Jet	Scan Tools And Tests
<i>Testing of Components</i>	Static Testing Resistance	Text	Text
<i>Jetting Modifiers</i>	Dial A Jet	Altitude Compensators	D P M
<i>Fuel Injection</i>	Types Battery and	Parts and Function	

Engine Overhaul

Failure Analysis	Abnormal Combustion	Overheat vs. Cold Seizure	Snow Scuff & Water Ingestion
	Foreign Matter	Excessive Clearances	Fuel & Ignition Failures
Compression Ratio	Corrected vs. Uncorrected	Effect of Altitude	Squish Band Clearances
Top End Overhaul	Cylinder Measurement	Cylinder Types	Cylinder Over sizing
	Cylinder Sleeving		
Bottom End Overhaul	Crank Inspection and Phase	Crankcase Sealing Methods	Crank Seal Types and Testing
	Crankshaft Rebuilding and Resealing		
Induction Methods	Piston Port	Reed Valve Cylinder and Case	Rotary Valve Operation and Timing
Exhaust Valves Page #	Theory of Porting	Operation of Exhaust Poser Valves	Type of Power Valves
	Servicing and Cleaning		

Cooling Systems

Fan Cooled Adjustments	Liquid Cooled	Water Pumps and Seals
Heat Exchangers and Flow Directions	Thermostats & Pressure Caps	Coolants & Bleeding of System

Accessories

Tracks	⇒	Types and Profiles	Pitch and Driver Styles	Installation & Clearances
---------------	---	--------------------	-------------------------	---------------------------

Traction Aids	⇒	Stud Types	Installation & Patterns	Cleats and Claws
----------------------	---	------------	-------------------------	------------------

Paddles

Exhaust Systems	⇒	Tuned Pipes, Mufflers and Stingers	Tune Pipe Theory	Horsepower Curves
------------------------	---	------------------------------------	------------------	-------------------

Effects of Pipe Temperature

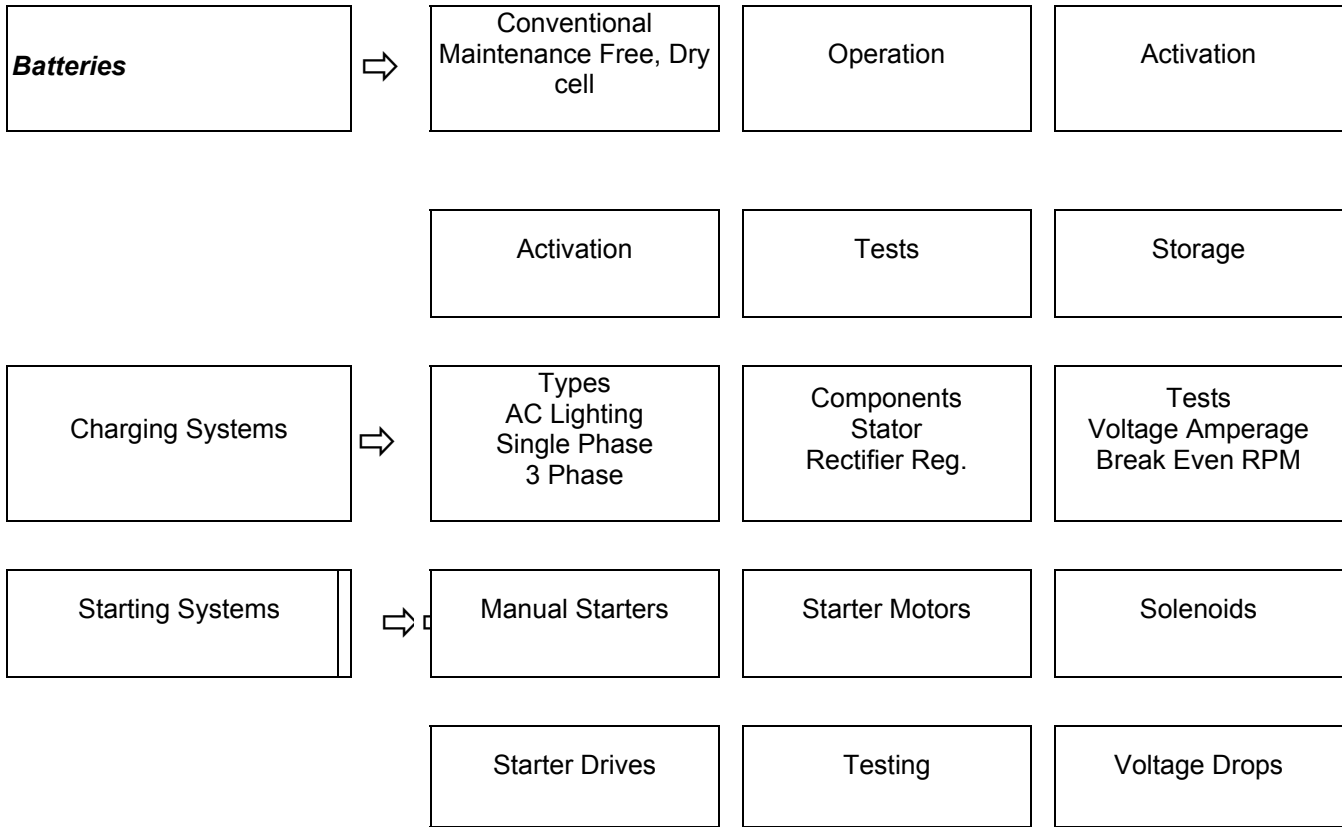
Heated Grips	⇒	Types	Installation in ac & dc	Troubleshooting
---------------------	---	-------	-------------------------	-----------------

Pyrometers	⇒	Types	Installation Location	Effect on Temperature with Location
-------------------	---	-------	-----------------------	-------------------------------------

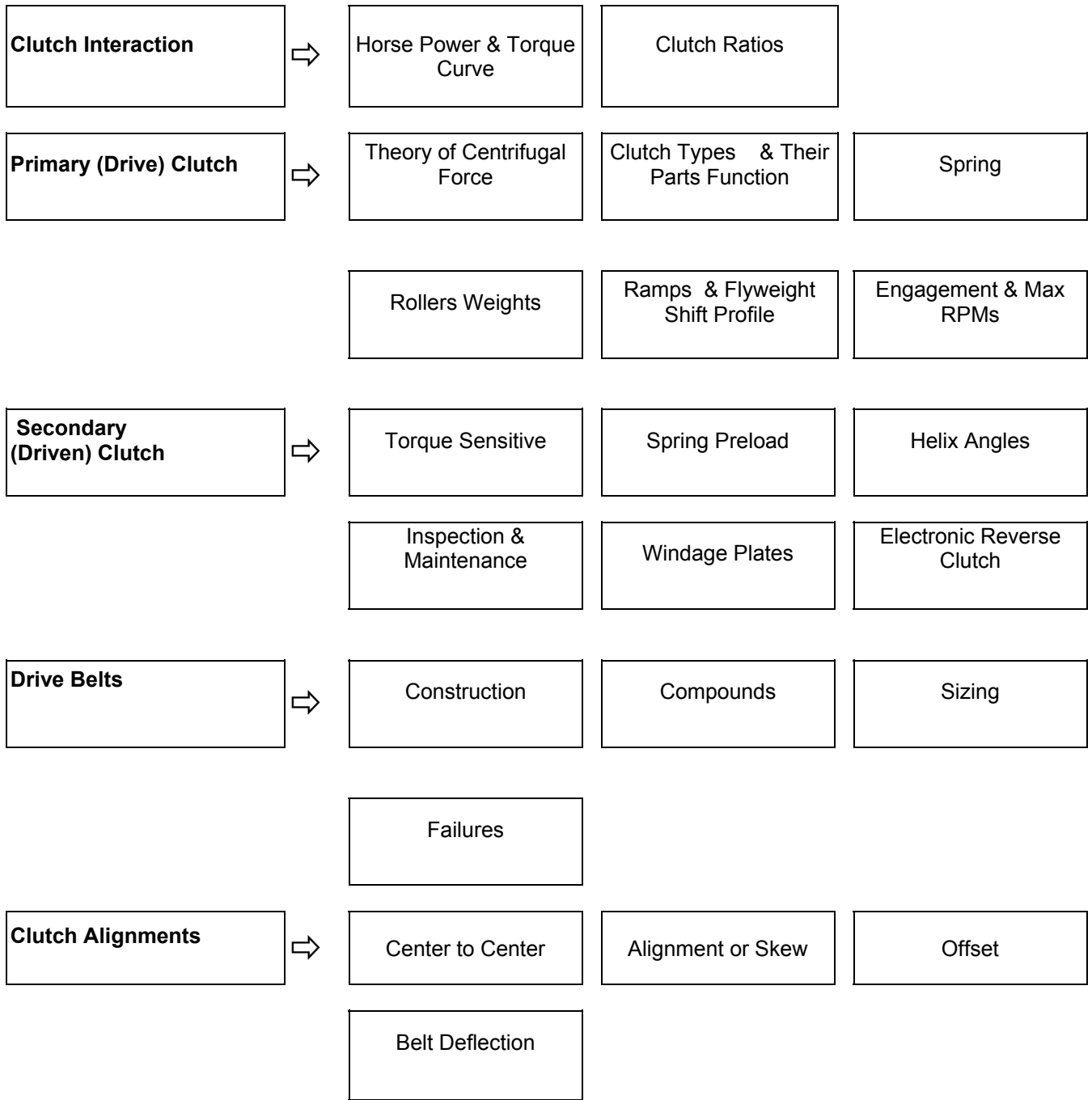
Ignitions

<i>Ignitions</i>				
<i>Magneto</i>	⇒	Points and Condensers	Direct and Indirect Timing	Mercotronic Testing
<i>CDI</i>	⇒	Theory	Magneto CDI	Battery CDI
		Digital CDI	Electronic Reverse	Text
<i>Components</i>	⇒	Trigger Coils	Charge Coils	Ignition Coils Single and Siamese
<i>Testing of Components</i>	⇒	Static Testing Resistance	Dynamic Testing	Digital Timing
<i>Kill Circuits</i>		Kill Switches	Throttle Safety Switch	Lanyard Switches
Page #		DESS		

Electronics



Clutches



Transmissions

TRANSMISSIONS

Chaincase



Gear Ratios

Chain Types

Inspection and
Adjustment

Chaincase Rolling
Effect on Track Attack
Angle

Jackshaft



Servicing and
Maintenance

Eccentric Collar
Bearings

Drivershaft



Removal and
Installation

Timing / Indexing/
Spacing

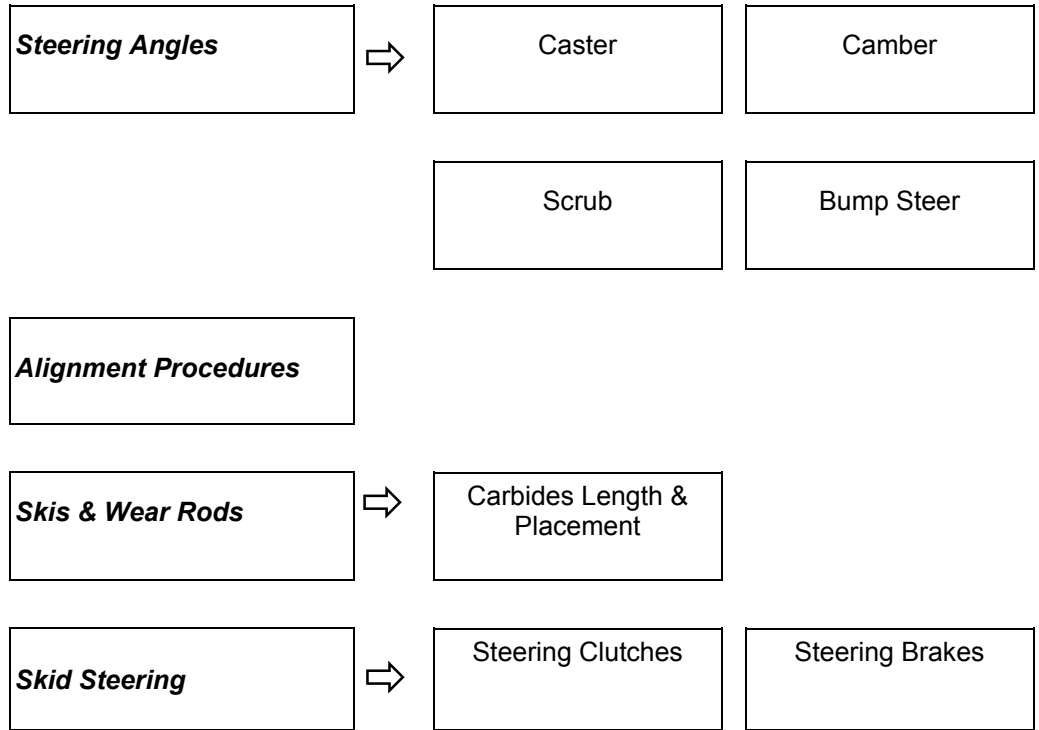
Driver Types Internal &
External

Pitch

Driver Size Effect on
Gear Ratio

Driver Size Effect on
Track Attack Angle

Steering



Suspension

SUSPENSION

Springs



Types – coil, torsion,
leaf

Spring Rates,
Preloads, Free Length

Inspection & Removal

Shocks



Compression &
Rebound

Hydraulic Shocks

High Pressure Gas

Floating Piston
Emulsion gas
Gas Bag

Shock Rebuilding

Precautions
Procedures
Tuning

Front Suspension



Leaf Spring

A Arm
Ball Joints

Trailing Arm

Telescopic Strut

Torsion Sway Bars

Rear Suspension



Torque Reaction

Slider

Bogie

Linked or Coupled

Rising / Progressive
Rate

Settings & Adjustments



Text

Weight Transfer
Rods / Stops

Ride Height
Spring Preload

General (from periods 1, 2, 3)

1. Understand the basic laws of electricity and be able to wire, diagnose and calculate values for the various circuits used in a marine application.
2. Know the types and proper use of precision measuring tools.
3. Describe and troubleshoot the various cooling systems used in recreational equipment engines.
4. Know the various engine designs, their advantages, disadvantages and the applications where they may be used.
5. Describe the operation of the two and four stroke engine, compare their relative volumetric efficiency.
6. Describe in detail the various types of power transmission systems found in recreational equipment.
7. Describe the common methods fuel is distributed to the combustion chamber.
8. Describe the common types of ignition systems.
9. Describe the purposes of exhaust systems.
10. Describe the typical service procedures for both two and four stroke engines.
11. Diagnose and describe failures to bearings and seals as well as understand the operation and placement of the various bearings and seals.
12. Describe the operation of a lead acid battery and the methods used to safely service and maintain the battery.
13. Describe the various starting and charging systems in use and the problems that may arise as a result of failures to any of the systems components.
14. Know P.D.I. procedures for (power – recreation – turf) equipment.
15. Understand the proper setup and service procedures used on equipment trailers.

Practice Questions

16. What is Ohm's law?
17. What are the three measurements that a vernier calliper can measure?
18. What controls engine temperature at idle? At W.O.T.?
19. Where does thrust related wear occur on bevel gears?
20. Why does an overhead cam engine have a higher maximum R.P.M. than a push rod engine?
21. What is valve float?
22. What is the difference between a loop charged engine and a cross scavenged engine?
23. What determines when the engine achieves the best volumetric efficiency on a four stroke? Two stroke?

NOTES

-
24. How will exhaust tuning increase the horsepower of the engine?
 25. What three things are required to produce electrical energy mechanically?
 26. What is the diode trio and what function does it serve in a charging system?
 27. What will the voltage drop test tell you about the starting circuit of an engine?
 28. How does the commutator and brushes of a starter motor change the direction of current flow in the armature of the starter motor?
 29. What is the affect of changing drive ratios on torque? Horsepower?
 30. How can you change the volumetric efficiency of a two stroke engine?

Fuel Systems

1. Know the components, which make up the fuel supply system and its venting system, and the safety concerns surrounding them.
2. Understand the operation and inspection of a *pulse type fuel pump*.
3. Explain the adjustment, bleeding, and testing procedures for an oil injection pump.
4. Understand the advantages of a variable venturi carburetor.
5. Identify all of the circuits in a slide type carburetor and their functional ranges.
6. Describe the operation of a diaphragm carburetor.
7. Know how a *constant velocity carburetor* functions and when an *anti backfire valve* comes into operation.
8. Shall be able to perform multiple carburetor synchronization and recognize the symptoms of their maladjustment.
9. Know how to confirm fuel mixtures by using plug readings, piston wash, or pyrometer reading methods.
10. Understand how float bowl pressure is modified in order to lean the fuel mixture on an altitude compensator system.
11. Describe the difference between *dial a jet* and *power jet* operation.
12. Know all of the components of a fuel injection system and their function.
13. Identify the differences between battery and battery-less fuel injection system.
14. Be able to diagnose a fuel injection problem using a scan tool and prescribed tests

Practice Questions for Fuel Systems

1. List 3 procedures that must be done to the oil injection pump during the PDI of a snowmobile.
2. What would it indicate if you observed fuel passing through the pulse line on a fuel pump?
3. At what throttle range is the slide cutaway effective and how does increasing it effect the fuel mixture?
4. What is the purpose of the float bowl vent lines and what would likely cause fuel to be running out of them?
5. How do you test the condition of the fuel inlet needle and seat on a diaphragm carburetor?
6. What 2 adjustments must be made in order to synchronize a pair of slide carburetors?
7. What effect will a pin hole in the diaphragm have on a constant velocity carburetor?
8. List 4 possible causes of a low fuel pressure reading on a fuel injected snowmobile.
9. How does the ECU of a fuel injection system determine engine load?
10. How do high altitude compensation systems modify the mixture within the carburetor?

Engine Overhaul

NOTES

1. Know the differences between *detonation* and *pre-ignition* and the causes of each.
2. Shall be able to identify the different types of piston failures.
3. Understand the difference between corrected and uncorrected compression ratios.
4. Identify the *squish band* and know its purpose.
5. Be able to perform cylinder and piston measurements to determine the need for cylinder over sizing or resleeving.
6. Know how to use the different products for crankcase sealing.
7. Identify the different types of crankshaft seals.
8. Know the procedures for inspecting and rebuilding built up crankshafts.
9. Identify the different methods of induction and understand the advantages and disadvantages of each.
10. Know how to time a rotary valve.
11. Understand the theories of port timing.
12. Explain the function of an exhaust power valve.
13. Be able to adjust fan belt deflection.
14. Understand the principles, which heat exchangers use to transfer engine heat.
15. Know how to bleed a cooling system depending on flow direction.
16. Troubleshoot for an overheat symptom.

Practice Questions for Engine Overhaul

1. List the effects that water in the fuel system can have on an engine.
2. List 5 causes of detonation.
3. How is corrected compression ratio measured?
4. Explain the function of the squish band.
5. Why is it important to seal the crankcase on a 2 stroke and how can it be tested?
6. How does raising the height of the exhaust port effect maximum RPM horsepower?
7. List the 3 ways which a multi cylinder press fit crankshaft can go out of alignment.
8. What must be done to the ports after boring a cylinder, and why?
9. Explain how scavenging occurs in a cylinder.
10. List 3 measurements which must be made to determine the need for cylinder over sizing

Accessories

NOTES

1. Identify a track by its type, profile, pitch, and width.
2. Know the problems, which can occur because of insufficient track to tunnel clearance.
3. Understand the direction and procedure to install a track.
4. Explain how to choose traction stud lengths and pattern.
5. Understand the theory of how a tuned pipe works, and be able to explain how this tuning effects maximum horsepower.
6. Know what changes must be also made when installing tuned pipes; in order to achieve the maximum performance gains.
7. Describe what effect temperature has on tuned pipe tuning.
8. Understand the different installation procedures for heated grips on AC lighting systems and DC charging systems.
9. Troubleshoot heated grip failures.
10. Know where to properly install pyrometer probes and what effect will be seen if improperly installed and why.

NOTES

Practice Questions for Accessories

1. What 3 items must you know when choosing a track for a particular unit?
2. Why is it so important to have sufficient track to tunnel clearance when installing a higher profile track?
3. Why is it important that the studs do not line up when laying out a pattern on a track?
4. Why are clutch adjustments usually necessary after installing an aftermarket tuned pipe?
5. What force does a tuned pipe use to help scavenge the cylinder on a 2 stroke?
6. List the names of the 5 parts of a tuned pipe.
7. How would removing the heat shielding on a tuned pipe effect it's function and why?
8. What could cause the lighting circuit to be dim on an electric start snowmobile when the heated grips are used?
9. Why is location of the pyrometer probes so critical?
10. What is the optimum temperature to see when jetting using pyrometers?

Ignitions

NOTES

1. Know the theory of operation of a *magneto ignition*.
2. Understand the difference between direct and indirect ignition timing.
3. Be able to troubleshoot a magneto with no spark.
4. Describe the operation of CD ignition.
5. List the components of a CD ignition.
6. Know the differences between magneto CDI and battery CDI.
7. Understand how digital ignition calculate and control timing.
8. Perform static resistance troubleshooting tests on a CD Ignition.
9. Perform dynamic output troubleshooting tests on a CD Ignition.
10. Understand how an electronic reverse ignition system functions.
11. Know how to test and adjust a throttle kill switch system.
12. List all of the kill switches that can cause a no spark condition.
13. Describe how a DESS lanyard and post work together to prevent theft.

Electronics

1. Describe the differences between conventional, maintenance free and dry cell batteries.
2. Understand the chemical reactions, which occur within a lead acid battery during charging and discharging phases.
3. List the steps to activate a brand new lead acid battery and calculate the appropriate charge rate for a given amp hr. battery.
4. Determine the condition of a battery by performing voltage, load, and specific gravity tests.
5. Know the proper procedures to prepare a battery for storage.
6. Understand the operation of an AC lighting system and the differences between single phase and 3 phase charging systems.
7. List the components of a charging System.
8. Troubleshoot a charging system problem using voltage output, amperage, and break even RPM tests to determine if there is a problem.
9. Understand how an electric starter operates.
10. Know how to perform a voltage drop test and understand the relationship between resistance and voltage drop.

Practice Questions for Ignitions and Electronics

NOTES

1. List the 3 tests, which should be done when checking the condition of a battery.
2. When activating a new battery, how long should you let it saturate and how would you determine the charge rate to use?
3. Why should you never add acid back into a battery once it has been activated?
4. How many diodes would you find in a full wave 3-phase rectifier?
5. If troubleshooting a charging system you observed high voltage and high amperage readings what would your verdict be?
6. List 5 items, which could result in high amperage draws when testing a starter circuit.
7. What would you consider as an excessive voltage drop and what does it tell you?
8. What is the difference between direct and indirect timing on a magneto?
9. Why must the timing on a digital ignition system be checked within a particular RPM range?
10. What peak voltages would you expect to read for a trigger coil, charge coil, and CDI Module?
11. How is a DESS Lanyard cap recognized by the security system?
12. If a customer brought in a snowmobile with no spark after he just installed a new throttle cable, what would be the first thing you would check?

Clutches and Transmission

1. Understand the interaction between drive and driven clutches on a CVT clutch system under varying loads and the gear ratios that result.
2. Know the theories of centrifugal force and the variables that effect it.
3. List the parts of a drive clutch and their function.
4. Describe how different spring pressures effects clutch RPM.
5. Know how increasing the weight of the flyweights will effect RPM.
6. Understand how ramp angles can control clutch shift rates.
7. Describe how to choose engagement and max. RPM using horsepower and torque graphs.
8. Understand why the driven clutch is referred to as being torque sensitive.
9. Know how spring preload and helix angle effect driven clutch shifting.
10. List the advantages and disadvantages of using windage plates on driven clutches.
11. Know the differences of an electronic reverse driven clutch.
12. Understand how drive belts are constructed and the compounds they are made with.
13. Be able to examine a failed drive belt and determine the cause of failure.
14. List the three clutch alignments that are vital for long belt life.
15. Understand how incorrect belt deflection effects clutch efficiency.
16. Troubleshoot for a clutching problem.
17. Calculate a chaincase gear ratio and determine an appropriate ratio for an application.
18. Explain how to properly adjust a chaincase chain.
19. Know the differences between a regular chaincase, and one with reverse.
20. List the advantages of rolling a chaincase.
21. Be able to replace drivers, including spacing, timing, and indexing.
22. Understand how driver pitch is changed by turning drivers on a lathe.
23. Explain how changing the number of driver teeth effects overall gear ratio.
24. Explain how changing the number of driver teeth effects track attack angle.

Practice Questions for Clutches and Transmission

NOTES

1. What are the functions of the drive and driven clutches?
2. List the 3 factors, which influence centrifugal force.
3. How would increasing spring pressure from 100lb/230lb to 150lb/230lb effect clutch operation?
4. At what RPM would increasing the flyweight make the most effect?
5. How does ramp angle effect shift pattern?
6. -How is the maximum RPM of a snowmobile actually controlled?
7. What effect does increasing the spring preload on the driven clutch have on the shifting?
8. How does the helix angle affect the shift pattern and belt pressure?
9. How would you lower the maximum engine RPM if clutching changes where no longer having any effect?
10. List the four clutch alignments.
11. On a TRA clutch how do the clickers work?
12. What are windage plates for, and when would you use them?
13. You should adjust the chain case adjuster to what torque?
14. How would changing the drivers from 9 tooth to 7 tooth effect the overall gear ratio and track attack angle

Steering and Suspensions

1. Know the three steering angles caster, camber, and toe out, and how each effect handling.
 2. Understand the alignment and adjustment procedures for the steering system.
 3. Describe scrub and explain how unequal length radius rods prevent it.
 4. describe bump steer.
 5. List the different types of suspension springs.
 6. Know how to inspect the different types of springs.
 7. Understand the operation and construction of hydraulic and gas shocks.
 8. Describe the procedures and precautions to use when rebuilding gas shocks.
 9. Explain how to tune a gas shock by adjusting shim thickness.
 10. Describe the torque reaction that occurs on a rear suspension during acceleration, and how the limiter strap controls it.
 11. Understand how to adjust a limiter strap for varying snow conditions.
 12. Describe the shock action on rising and falling rate suspensions.
 13. Explain how weight transfer rods or stops control weight transfer during acceleration.
 14. Understand how linked or coupled rear suspension reacts as a bump is struck.
 15. Explain why it is critical to set ride height for a suspension to operate correctly.
 16. Inspect sliders for wear and determine the need for replacement.
 17. Understand how a bogie suspension works.
-
1. What would you inspect the slider material for to determine the need for replacement?
 2. How does track attack angle effect the snowmobile's ability to go through deep snow?

Practice Questions for Steering and Suspensions

NOTES

1. What effect does positive or negative camber have on handling?
2. Why do you never want toe-in on a snowmobile?
3. What is scrub?
4. When does bump steer occur?
5. How are carbide inserts attached to the wear bars?
6. Why is it critical to set the spring preload for each rider's weight?
7. When installing a softer spring for a lighter rider, what must be done to the shock to keep suspension balanced?
8. How does lengthening the limiter strap effect torque transfer and ski pressure?
9. What is meant by a rising or progressive rate suspension?
10. What is the purpose of the high pressure nitrogen in a gas shock?

NOTES

References

Ski-Doo Product Familiarization

Ski-Doo Electrical Troubleshooting

Yamaha Suspension Systems

Arctic Cat Update Manuals

Polaris Service Manual

Aaen Clutch Tuning Handbook

Aaen Mikuni Carb Tuning Handbook



*Alberta Apprenticeship
Excellence Through
Training and Experience*

ALL RIGHTS RESERVED:

2002, Her Majesty the Queen in right of the Province of Alberta, as represented by the Minister of Alberta Learning, 10th floor Commerce Place, Edmonton, Alberta, Canada, T5J 4L5. All rights reserved. No part of this material may be reproduced in any form or by any means, without the prior written consent of the Minister of Alberta Learning.



**Printed in Canada
on Recycled Paper**