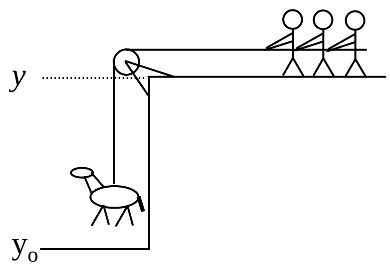
PH203 Phase Line Writ 3, Fall 2004 Name: ______________________

Lesson 36 / 50 Marks / 30 Minutes Section ___________ A Hour

Authorized References: Calculator, Physics Reference Card

Wt.	No.	
50	1.	While on a dismounted patrol with your infantry platoon in the mountains of Afghanistan, you come across a local villager whose 273-kg donkey fell over a cliff. You help the villager by hanging a pulley with a mass of 22.4 kg out from the edge of the cliff and running a rope over the pulley and down to the donkey. Your soldiers pull the other end of the rope and lift the donkey from rest with a constant acceleration to the top of the 7.56 m cliff in 5.15 s. Model the pulley as a disk. Assume that there is no friction on the pulley axle and that the rope is massless and passes over the pulley without slipping.

(0) a. Sketch the situation.



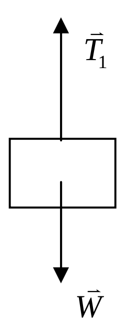
(4) b. List all given information and any assumptions.

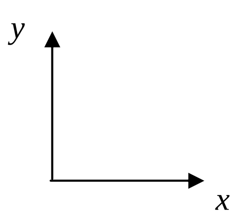
mass of donkey (m) = 273 kg   mass of pulley (M) = 22.4 kg

$y - y_o = 7.56$ m $t = 5.15$ s

model pulley as a disk, donkey starts from rest ($v_{yo} = 0$), frictionless pulley axle, constant vertical acceleration, rope does not slip around pulley

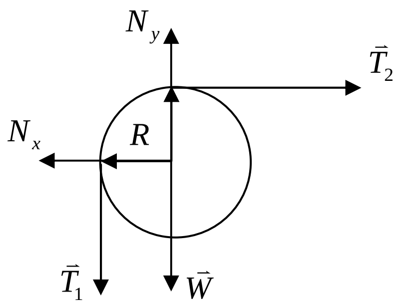
(10) c. Construct a free-body diagram of the donkey, and write the equation that governs the donkey's motion by applying Newton's second law.

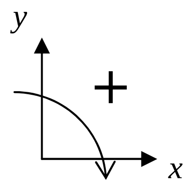




$$\underline{\underline{T - mg = ma_y}} \quad \text{ANS}$$

(16) d. Construct a free-body diagram of the pulley, and write the equation that governs the pulley's motion by applying Newton's second law for rotation.





$$\underline{\underline{RT_2 - RT_1 = I\alpha}} \quad \text{ANS}$$

(3) e. Write the algebraic expression for the rotational inertia of the pulley in terms of its mass and radius.

$$\underline{\underline{I = \frac{1}{2}MR^2}} \quad \text{ANS}$$

(5) f. Calculate the acceleration of the donkey.

$$\underline{\underline{a_y = 0.570\,\frac{\text{m}}{\text{s}^2}}} \quad \text{ANS}$$

(12) g. Calculate the magnitude of the force exerted on the rope by your soldiers.

$$\underline{\underline{T_2 = 2840\text{ N}}} \quad \text{ANS}$$

PH203 Phase Line Writ 3, Fall 2004 — Name: ____________________

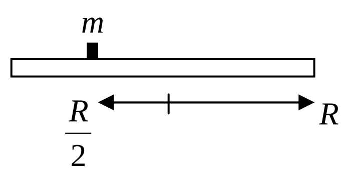
Lesson 36 / 50 Marks / 30 Minutes — Section __________ C Hour

Authorized References: Calculator, Physics Reference Card

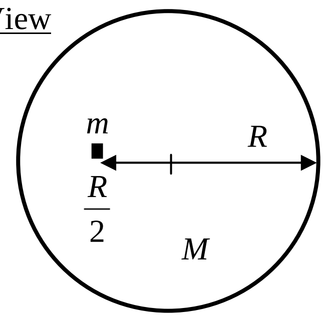
<u>Wt.</u>	<u>No.</u>	
50	1.	You are a researcher at an Army laboratory. You mount a disk with mass 42.5 kg and radius 52.5 cm on a vertical, frictionless axle through the disk's central axis. On the top surface of the disk, you place a small block with mass 0.500 kg exactly half way between the axis and the disk's edge. You then wrap a massless cord around the edge of the disk. You pull on the cord with a constant force, which causes the disk to accelerate from rest to an angular speed of 3.29 rad/s in 2.11 s. The cord does not slip relative to the edge of the disk, and the block remains in place on the disk's surface.

(0) a. Sketch the situation.

<u>Side View</u>



<u>Top View</u>



(4) b. List all given information and any assumptions.

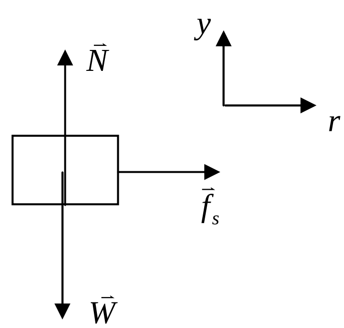
Mass of disk (M) = 42.5 kg mass of block (m) = 0. 500 kg

t = 2.11 s ω = 3.29 rad/s R = 0.525 m block placed at R/2

no friction in disk axle, constant force, constant angular acceleration, disk starts from rest ($\omega_o = 0$), cord does not slip, block does not slide

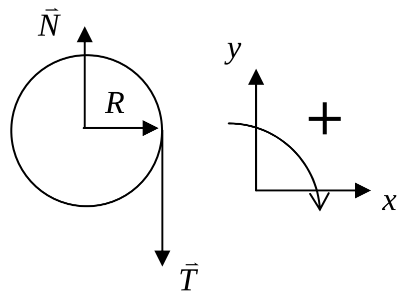
(11) c. Construct a free-body diagram of the block on the disk, and write the equations that govern the block's motion by applying Newton's second law.

$\underline{\underline{N = mg}}$ ANS



$\underline{\underline{f_s = \dfrac{2mv^2}{R}}}$ ANS

(13) d. Construct a free-body diagram of the disk, and write the equation that governs the disk's motion by applying Newton's second law for rotation.



$\underline{\underline{RT = I\alpha}}$ ANS

(14) e. Calculate the combined rotational inertia of the disk and block about the disk's central axis.

$\underline{\underline{I_{total} = 5.89\ \text{kg} \bullet \text{m}^2}}$ ANS

(4) f. Calculate the angular acceleration of the disk.

$\alpha = 1.56\ \text{rad/s}^2$

(4) g. Calculate the magnitude of the force you exert on the cord.

$\underline{\underline{T = 17.5\ \text{N}}}$ ANS

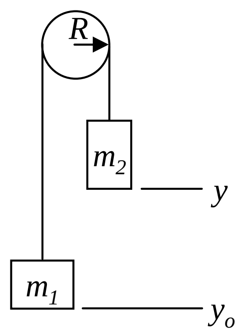
PH203 Phase Line Writ 3, Fall 2004 — Name: ________________________

Lesson 36 / 50 Marks / 30 Minutes — Section ____________ G Hour

Authorized References: Calculator, Physics Reference Card

Wt.	No.	
50	1.	You are a maintenance platoon leader for a light infantry unit. The winch you use to raise engines out of vehicles is broken, but your battalion XO has directed you to change the engine in his HMMWV today. To accomplish this, you run a rope over a large pulley (mass 33.4 kg) suspended from the motor pool ceiling. You tie one end of the rope to a big empty garbage can and the other end to the HMMWV engine (mass 229 kg). Before securing the end of the rope to the engine, you pull on it until the bottom of the garbage can is 1.92 m above the floor. You hold the garbage can in place, fill it with water, and then release it from rest to lift the engine. This causes the rope to exert a constant, upward force of 2280 N on the engine. It takes 4.82 s for the garbage can to reach the ground. Assume the rope does not slip. Model the pulley as a disk, and assume that there is no friction at the pulley's axle.

(0) a. Sketch the situation



(4) b. List all given information and any assumptions.

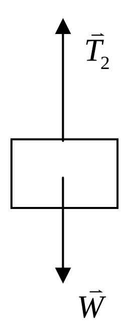
Mass of pulley (M) = 33.4 kg   mass of engine (m_1) = 229 kg

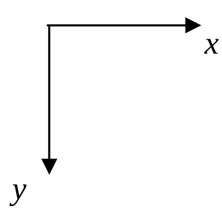
$y - y_o = 1.92$ m $t = 4.82$ s $v_{yo} = 0$

rope exerts force of 2280 N on engine (equal to T_1)

No friction, rope does not slip on pulley, pulley is a disk, constant acceleration

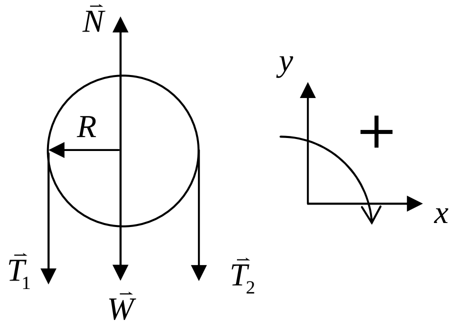
(10) c. Construct a free-body diagram of the garbage can, and write the equation that governs the can's motion by applying Newton's second law.





$$\underline{\underline{m_2 g - T_2 = m_2 a_y}} \quad \text{ANS}$$

(16) d. Construct a free-body diagram of the pulley, and write the equation that governs the pulley's motion by applying Newton's second law for rotation.



$$\underline{\underline{RT_2 - RT_1 = I\alpha}} \quad \text{ANS}$$

(3) e. Write the algebraic expression for the rotational inertia of the pulley in terms of its mass and radius.

$$\underline{\underline{I = \frac{1}{2}MR^2}} \quad \text{ANS}$$

(5) f. Calculate the acceleration of the garbage can.

$$\underline{\underline{a_y = 0.156\,\frac{\text{m}}{\text{s}^2} \quad \text{or} \quad 0.165\,\frac{\text{m}}{\text{s}^2}}} \quad \text{ANS}$$

(12) g. Calculate the mass of the garbage can when filled with water.

$$\underline{\underline{m_2 = 237\ \text{kg}}} \quad \text{ANS}$$

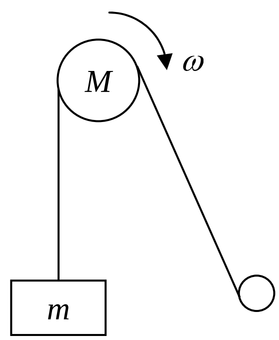
PH203 Phase Line Writ 3, Fall 2004 — Name: ________________________

Lesson 36 / 50 Marks / 30 Minutes — Section ___________ I Hour

Authorized References: Calculator, Physics Reference Card

Wt.	No.	
50	1.	You are an ordnance officer working at a forward support base in Afghanistan. Your unit often lifts heavy crates of materials into trucks for shipment to the units that you support. To make this job easier for your soldiers, you suspend a pulley from the ceiling of the warehouse; the pulley has mass 12.5 kg and radius 10.5 cm. You attach a rope to the crate you want to lift, run the rope over the pulley, and secure the rope to a winch. The winch pulls on the rope with a force of 785 N, which causes the pulley to rotate with an angular speed $\omega(t) = 6.11t$ (ω and t in SI units) while the crate rises. Assume that the rope has no mass and does not slip on the pulley. Model the pulley as a disk, and assume that there is no friction at the axle.

(0) a. Sketch the situation.



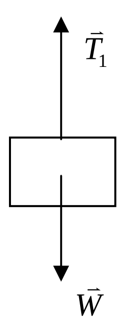
(4) b. List all given information and any assumptions.

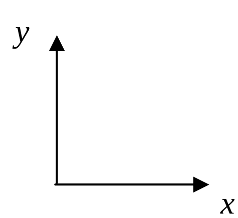
mass of pulley (M) = 12.5 kg   radius of pulley (R) = 0.105 m

winch exerts a force of 785 N on the rope $\omega(t) = 6.11t$

massless rope, rope does not slip, pulley is a disk, no friction at pulley axle, angular acceleration is constant, crate starts from rest ($v_{yo} = 0$), initial angular speed of pulley is zero ($\omega_o = 0$)

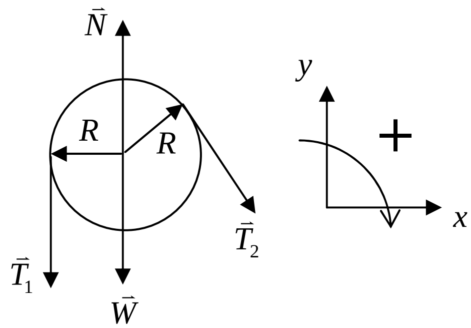
(10) c. Construct a free-body diagram of the crate, and write the equation that governs the crate's motion by applying Newton's second law.





$\underline{\underline{T_1 - mg = ma_y}}$ ANS

(16) d. Construct a free-body diagram of the pulley, and write the equation that governs the pulley's motion by applying Newton's second law for rotation.



$$\underline{\underline{RT_2 - RT_1 = I\alpha}} \quad \text{ANS}$$

(3) e. Write the algebraic expression for the rotational inertia of the pulley in terms of its mass and radius.

$$\underline{\underline{I = \frac{1}{2}MR^2}} \quad \text{ANS}$$

(8) f. Calculate the angular acceleration of the pulley.

$$\underline{\underline{\alpha = 6.11\,\text{rad/s}^2}} \quad \text{ANS}$$

(9) g. Calculate the mass of the crate.

$$\underline{\underline{m = 74.8\,\text{kg}}} \quad \text{ANS}$$