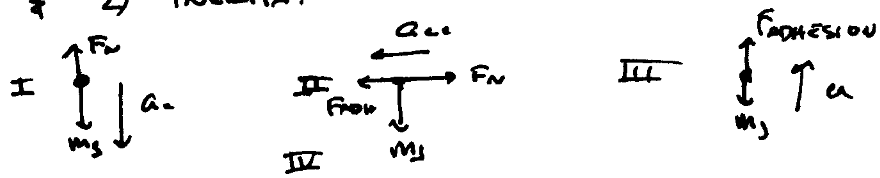
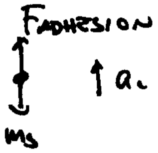
ENERGY

1.) C

AT THE BOTTOM OF THE FLY WHEEL, THE ANT HAS TO OVERCOME 1) GRAVITY & 2) INERTIA.



2.) E



$ma_c = F - mg$

$F = mg + ma$

$\boxed{F = mg + mr\omega^2}$

$a_c = \frac{v^2}{r} = \frac{(r\omega)^2}{r} = \omega^2 r$

3.) C

$I = I_{cm} + mh^2$

$= \frac{1}{2}mR^2 + mR^2$

$\boxed{I = \frac{3}{2}mR^2}$

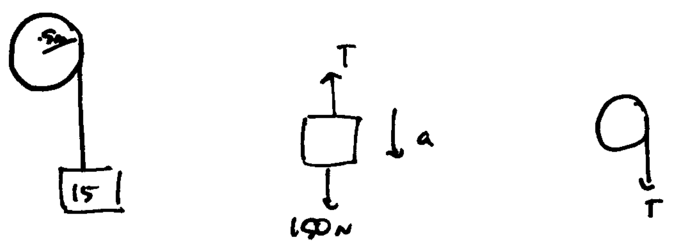
4.) C

$2mL^2$

$I = I_1 + I_2$

$= mL^2 + mL^2$

5.) B



$ma = 150N - T$

$15a = 150N - T$

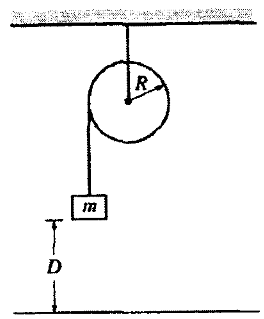
$.5\frac{a}{(.5)^2} = T$

$17a = 150$

$\boxed{a = 8.8 m/s^2}$

$\Sigma\tau = I\alpha = Tr$

$= 0.5 kgm^2 \frac{a}{r_0} = Tr$



Mech. 2.

A solid disk of unknown mass and known radius R is used as a pulley in a lab experiment, as shown above. A small block of mass m is attached to a string, the other end of which is attached to the pulley and wrapped around U several times. The block of mass m is released from rest and takes a time t to fall the distance D to the floor.

(a) Calculate the linear acceleration a of the falling block in terms of the given quantities.

$\Delta x = V_0 t + \frac{1}{2} a t^2$

$D = \frac{1}{2} a t^2$ $\quad \boxed{a = \frac{2D}{t^2}}$

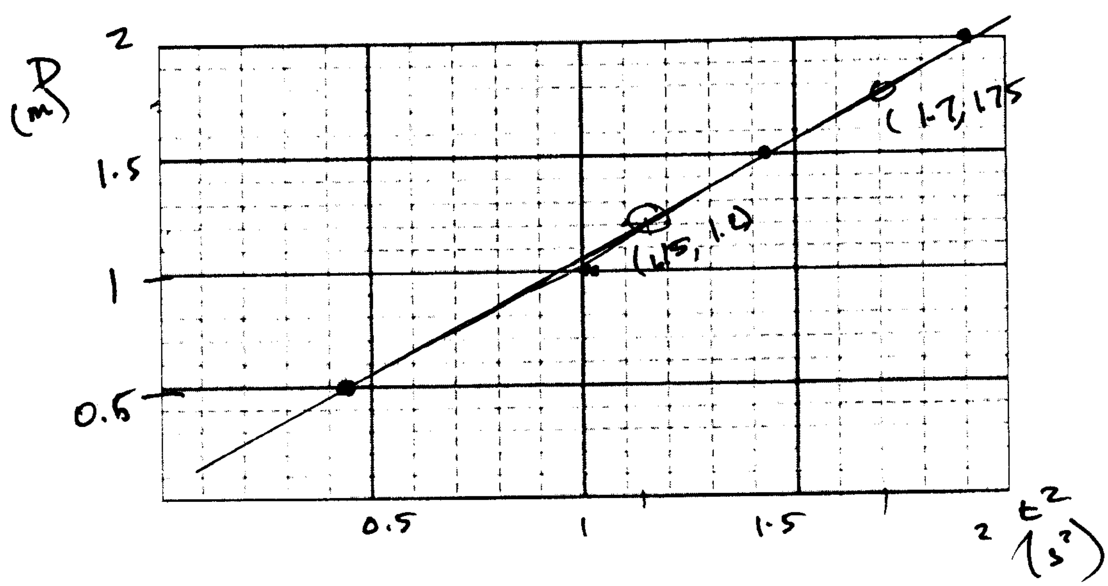
(b) The time t is measured for various heights D and the data are recorded in the following table.

D(m)	t (s)	t^2
0.5	0.68	.46
1	1.02	1.04
1.5	1.19	1.42
2	1.38	1.90

i. What quantities should be graphed in order to best determine the acceleration of the block? Explain your reasoning. $\quad D = \frac{at^2}{2} \quad D \propto t^2$

- RELATIONSHIP IS LINEAR

ii. On the grid below, plot the quantities determined in (b)i., label the axes, and draw the best-fit line to the data.



iii. Use your graph to calculate the magnitude of the acceleration.

(1.15, 1.2)
(1.7, 1.75)

$\text{Slope} = \frac{1.75-1.2}{1.7-1.15}$

$= 1$

$\text{Slope} = \frac{a}{2}$

$1 = \frac{a}{2}$

$2 = a$

(c) Calculate the rotational inertia of the pulley in terms of m, R, a, and fundamental constants.

$I\alpha = Tr$

$ma = mg - T$

$mr^2\alpha = rmg - Tr$

$mr^2\alpha = rmg - Tr$

$(I + mr^2)\alpha = rmg$

$\boxed{a = r\alpha \quad \alpha = a/r}$

$I = \frac{rmg}{\alpha} - mr^2$

$\boxed{I = \frac{mr^2 g}{a} - mr^2}$

(d) The value of acceleration found in (b)iii, along with numerical values for the given quantities and your answer to (c), can be used to determine the rotational inertia of the pulley. The pulley is removed from its support and its rotational inertia is found to be greater than this value. Give one explanation for this discrepancy.

- CANNOT BE FRICTION (FRICTION WOULD YIELD A RESULT THAT IS LESS THAN ACTUAL I)

- WRAPPING STRING AROUND PULLEY COULD ADD TO EFFECTIVE I.

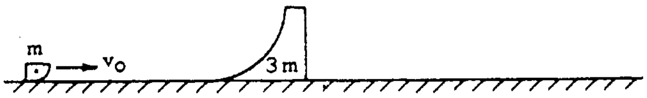


Figure I

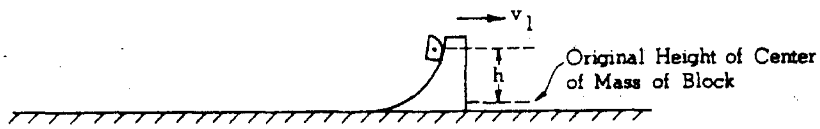


Figure II

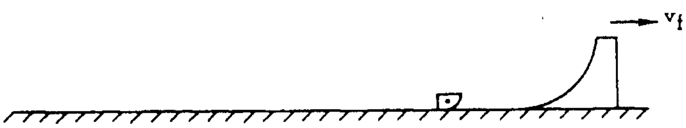


Figure III

1980M2. A block of mass m slides at velocity v_0 across a horizontal frictionless surface toward a large curved movable ramp of mass 3m as shown in Figure 1. The ramp, initially at rest, also can move without friction and has a smooth circular frictionless face up which the block can easily slide. When the block slides up the ramp, it momentarily reaches a maximum height as shown in Figure II and then slides back down the frictionless face to the horizontal surface as shown in Figure III.

a. Find the velocity v_1 of the moving ramp at the instant the block reaches its maximum height.

- MOVING WITH SAME VELOCITY → INELASTIC COLLISION.

$$mv_0 + 3m(0) = 4mv_1$$

$$\boxed{\frac{\cancel{m}v_0}{4} = v_1}$$

b. To what maximum height h does the center of mass of the block rise above its original height?

- KINETIC ENERGY LOST BECOMES POTENTIAL

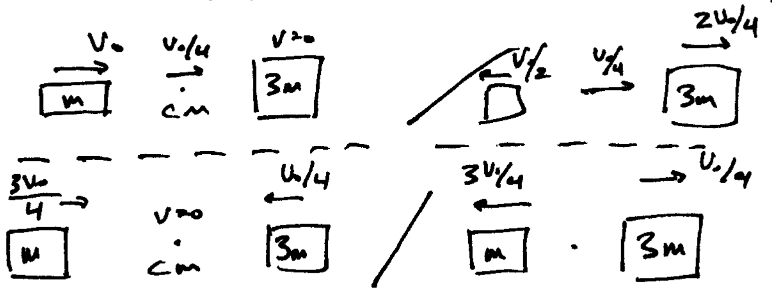
$$\Delta K = K_f - K_i$$
$$= \frac{1}{2}(4m)v_1^2 - \frac{1}{2}mv_0^2$$
$$= \frac{1}{2}4m\left(\frac{\cancel{m}v_0}{4}\right)^2 - \frac{1}{2}mv_0^2$$
$$= \frac{mv_0}{8} - \frac{1}{2}mv^2 = -\frac{3mv_0}{8}$$

$$\Delta K = -\Delta U$$
$$\frac{3\cancel{m}v_0^2}{8} = \cancel{m}gh$$
$$\boxed{\frac{3v_0^2}{8g} = h}$$

c. Determine the final speed v_f of the ramp and the final speed v' of the block after the block returns to the level surface. State whether the block is moving to the right or to the left.

- NOW NO KE LOSS → COLLISION IS ELASTIC

$$V_{cm} = \frac{V_0}{4}$$



BLOCK
$\frac{V_0}{2} \leftarrow$

RAMP
$\frac{V_0}{2} \rightarrow$

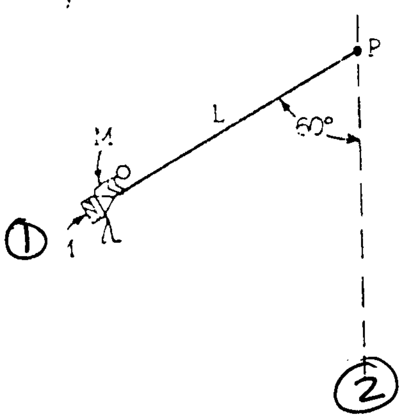


Figure I

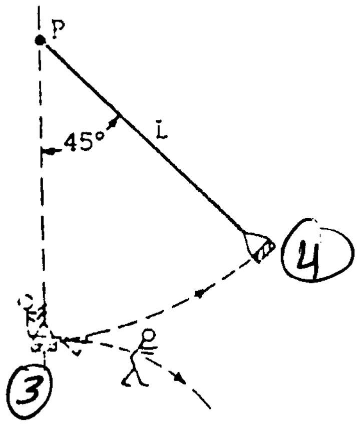


Figure II

1981M2. A swing seat of mass M is connected to a fixed point P by a massless cord of length L. A child also of mass M sits on the seat and begins to swing with zero velocity at a position at which the cord makes a 60° angle with the vertical is shown in Figure I. The swing continues down until the cord is exactly vertical at which time the child jumps off in a horizontal direction. The swing continues in the same direction until its cord makes a 45° angle with the vertical as shown in Figure II: at that point it begins to swing in the reverse direction. With what velocity relative to the ground did the child leave the swing? ($\cos 45° = \sin 45° = \sqrt{2}/2$, $\sin 30° = \cos 60° = 1/2$, $\cos 30° = \sin 60° = \sqrt{3}/2$)

ENERGY

1 TO 2

$$2mgh = \frac{1}{2}(2m)v^2$$

$$g(L - L\cos 60) = \frac{1}{2}v^2$$

$$g(L - .5L) = \frac{1}{2}v^2$$

$$\cancel{\tfrac{1}{2}}gL = \cancel{\tfrac{1}{2}}v^2$$

$$\sqrt{gL} = V_2$$

MOMENTUM

2 TO 3

$$2m(\sqrt{gL}) = m(\sqrt{gL}\sqrt{2-\sqrt{2}}) + mV$$

$$\boxed{2\sqrt{gL} - \sqrt{gL(2-\sqrt{2})} = V}$$

$$2\sqrt{gL} - \sqrt{gL(2-\sqrt{2})} = V$$

ENERGY 3 TO 4

$$\frac{1}{2}mV_3^2 = mgh$$

$$\frac{1}{2}V_3^2 = g(L - L\cos 45)$$

$$\frac{1}{2}V_3^2 = g\left(L - L\frac{\sqrt{2}}{2}\right)$$

$$V_3^2 = 2gL\left(\frac{2-\sqrt{2}}{2}\right)$$

$$V_3 = \sqrt{gL(2-\sqrt{2})}$$

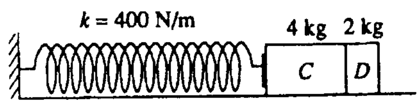


Figure I

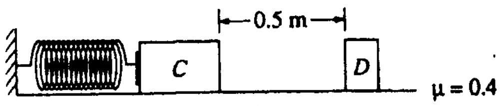


Figure II

1993M1. A massless spring with force constant k = 400 newtons per meter is fastened at its left end to a vertical wall, as shown in Figure 1. Initially, block C (mass m_c = 4.0 kilograms) and block D (mass m_D = 2.0 kilograms) rest on a horizontal surface with block C in contact with the spring (but not compressing it) and with block *D* in contact with block C. Block C is then moved to the left, compressing the spring a distance of 0.50 meter, and held in place while block *D* remains at rest as shown in Figure 11. (Use g = 10 m/s^2.)

a. Determine the elastic energy stored in the compressed spring.

$U_s = \frac{1}{2}Kx^2$

$= \frac{1}{2}(400\ N/m)(.5\ m)^2$

$\boxed{U_s = 50J}$

Block C is then released and accelerates to the right, toward block *D*. The surface is rough and the coefficient of friction between each block and the surface is μ = 0.4. The two blocks collide instantaneously, stick together, and move to the right. Remember that the spring is not attached to block C. Determine each of the following.

b. The speed v_c of block C just before it collides with block *D*

$E_1 = E_2$

$50J = K + W_f$

$50J = \frac{1}{2}mv^2 + 40(.4)(.5$

$50J = \frac{1}{2}(4)v^2 + 8$

$\cancel{42} = \frac{1}{2}v^2$

~~V = 8.24 m/s~~

$50 = \frac{1}{2}(4)v^2 + 8$

$21 = v^2$

$\boxed{4.6\ m/s = V}$

c. The speed v_f blocks C and *D* just after they collide

$4.6\ m/s\ (4) + 0(2) = 6V$

$3.1\ m/s = v$

d. The horizontal distance the blocks move before coming to rest

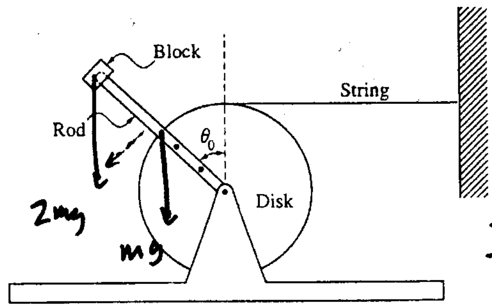
$\frac{1}{2}mv^2 = W_f$

$\frac{1}{2}mv^2 = 60(.4)d$

$\frac{1}{2}(6)(3.1)^2 = 24d$

$28.83 = 24d$

$1.2m = d$



$$I = I_{DISC} + I_{ROD} + I_{MASS}$$
$$= 1.5mR^2 + \frac{4}{3}mR^2 + 2m(2R)^2$$
$$I = 10.83mR^2 = \frac{65}{6}mR^2$$

1999M3 As shown above, a uniform disk is mounted to an axle and is free to rotate without friction. A thin uniform rod is rigidly attached to the disk so that it will rotate with the disk. A block is attached to the end of the rod. Properties of the disk, rod, and block are as follows.

Disk: mass = 3m, radius = R, moment of inertia about center $I_D = 1.5mR^2$

Rod: mass = m, length = 2R, moment of inertia about one end $I_R = 4/3(mR^2)$

Block: mass = 2m

The system is held in equilibrium with the rod at an angle θ_0 to the vertical, as shown above, by a horizontal string of negligible mass with one end attached to the disk and the other to a wall. Express your answers to the following in terms of m, R, θ_0, and g.

a. Determine the tension in the string.

$$\Sigma\tau = 0 = T(R) - 2mg(2R)\sin\theta - mgR\sin\theta$$
$$TR = 4mgR\sin\theta + mgR\sin\theta$$
$$\cancel{R = 5mg}s$$
$$\boxed{T = 5mg\sin\theta}$$

The string is now cut, and the disk-rod-block system is free to rotate.

b. Determine the following for the instant immediately after the string is cut.

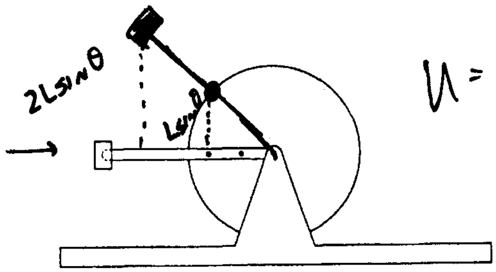
i. The magnitude of the angular acceleration of the disk

$$\Sigma\tau = I\alpha = 2mg(2R)\sin\theta + mgR\sin\theta$$
$$\frac{65}{6}\cancel{m}R^2\alpha = 5\cancel{m}gR\sin\theta$$
$$\alpha = \frac{6}{13}\frac{g\sin\theta}{R}$$

ii. The magnitude of the linear acceleration of the mass at the end of the rod

$$a = r\alpha$$
$$a = 2\cancel{R}\left(\frac{6}{13}\frac{g\sin\theta}{\cancel{R}}\right)$$
$$a = \frac{12}{13}g\sin\theta$$

$E = U$



$U = 2mgh_1 + mgh_2$

$E = K$

As the disk rotates, the rod passes the horizontal position shown above.

b. Determine the linear speed of the mass at the end of the rod for the instant the rod is in the horizontal position.

$$U = 2mg(2R\sin\theta) + mgR\sin\theta$$

$$U = 5mgR\sin\theta$$

$$5mgR\sin\theta = \frac{1}{2} I\omega^2$$

$$2\,\cancel{10}\, mgR\sin\theta = \frac{\overset{13}{\cancel{65}}}{6} MR^2\omega^2$$

$$\frac{12}{13}\,\frac{g\sin\theta}{R} = \omega^2$$

$$V = r\omega$$

$$\cancel{V = 2R\omega}$$

$$V = 2R\sqrt{\frac{12}{13}\,\frac{g\sin\theta}{R}}$$