PHYS 101 Midterm Examination #2 (version A)

March 11, 2011

Time: 50 minutes

Last Name : Key

First Name : ____________

Student No. : ____________

Computing ID : ____________

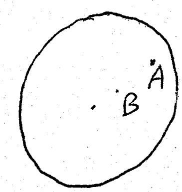
Tutorial Section : ____________

	score	***Maximum***
Multiple Choice #1-5		***5***
Written # 6		***5***
Written # 7		***5***
Written # 8		***5***
Total		***20***

Part I (Multiple choice questions. 1 mark each.)

1. Two points, A and B, are on a disk that rotates about an axis. Point A is three times as far from the axis as point B. If the speed of point B is v, what is the speed of point A?

   A) v
   B) 3v
   C) v/3
   D) 9v
   E) $\sqrt{3}$ v



2. A disk, a hoop, and a solid sphere are released at the same time at the top of an inclined plane. They all roll without slipping. In what order do they reach the bottom?

   A) sphere, disk, hoop
   B) sphere, hoop, disk
   C) disk, hoop, sphere
   D) disk, sphere, hoop
   E) hoop, sphere, disk

3. A uniform steel wire was cut into two pieces. The first piece is 2.0 meters long and the second piece is 20meters long. The Young's modulus of the first piece is Y. What is the Young's modulus of the second piece?

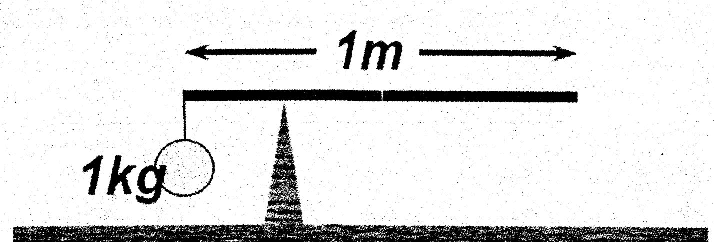
   A) 100Y
   B) 10Y
   C) Y
   D) 0.1Y
   E) 0.01Y

4. Two disks are cut from the same metal sheet. Disk A has a radius R and a moment of inertia I, while disk B has a radius 2R. What is the moment of inertia of disk B?

   A) I
   B) 2I
   C) 4I
   D) 8I
   E) 16I

5. A 1-kg ball is hung at the end of a rod 1-m long. If the system balances at a point on the rod 0.25 m from the end holding the mass, what is the mass of the rod?

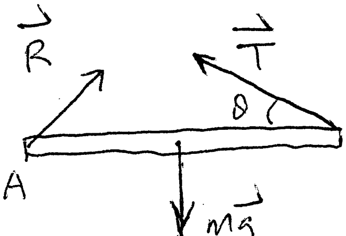
   A) 0.25 kg
   B) 0.50 kg
   C) 1 kg
   D) 2 kg
   E) 4 kg

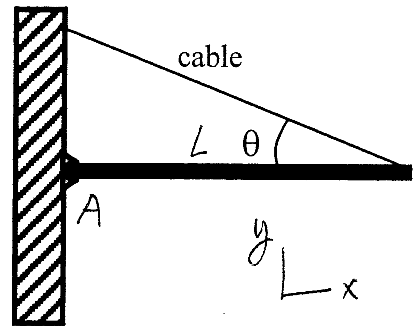


Part II (Full solution questions, 5 marks each. **SHOW ALL WORK FOR FULL MARKS!**)

6. A uniform beam, 1.50 m long with mass m = 4.00 kg, is mounted by a small hinge on a wall (the frictional torque at the small hinge is negligible). The beam is held in a horizontal position by a cable that makes an angle θ = 25.0° with the beam.
(a) Find the magnitude of the force exerted by the hinge on the beam (show your free body diagram of the beam).
(b) If the cable breaks, the beam will start to rotate about the hinge. Find the angular acceleration of the beam.

(a). FBD





$\Sigma \vec{F} = 0$: $R_x - T\cos\theta = 0$

$R_y + T\sin\theta - mg = 0$

$\Sigma \tau = 0$: (about A):

$TL\sin\theta - mg\frac{L}{2} = 0$

$T = \frac{mg}{2\sin\theta} = \frac{4\times 9.8}{2\times \sin 25°} = 46.4N$

$R_x = T\cos\theta = 42.0\ N$.

$R_y = mg - T\sin\theta$

$= 4\times 9.8 - 46.4\times \sin 25°$

$= 19.6N$

$R = \sqrt{R_x^2 + R_y^2}$

$= \sqrt{(42.0)^2 + (19.6)^2}$

$= 46.3\ N$

(b). $\tau = -mg\frac{L}{2}$

$I = \frac{1}{3}mL^2$.

$\alpha = \frac{\tau}{I}$

$= -\frac{mg\frac{L}{2}}{\frac{1}{3}mL^2}$

$= -\frac{3g}{2L}$

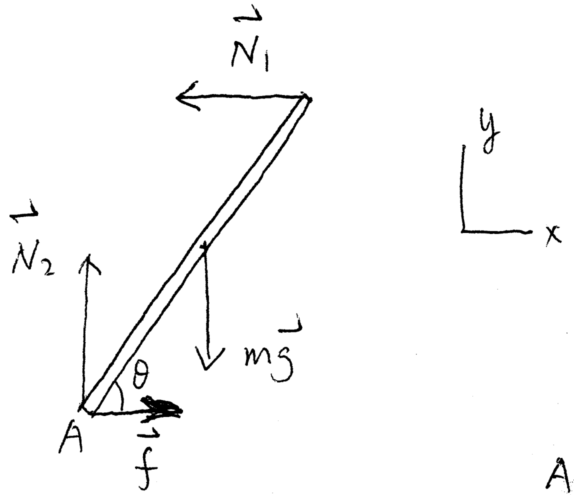
$= -\frac{3\times 9.8}{2\times 1.5}$

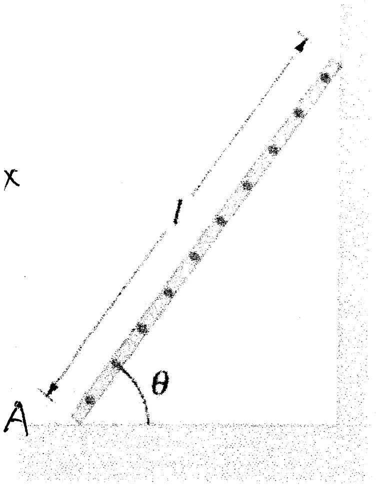
$= -9.8\ rad/s^2$

Answer 6(a): 46.3 N

Answer 6(b): $-9.8\ rad/s^2$

7. A uniform ladder of mass M=6.0kg and length L=4.0m leans against a frictionless wall at an angle θ=60° . Determine the frictional force between the ladder and the ground. Include a free body diagram of the ladder.





$\Sigma \vec{F} = 0$: $f - N_1 = 0$

$N_2 - Mg = 0$

$\Sigma \tau = 0$ (About point A).

$$N_1 L \sin\theta - mg \frac{L}{2} \cos\theta = 0$$

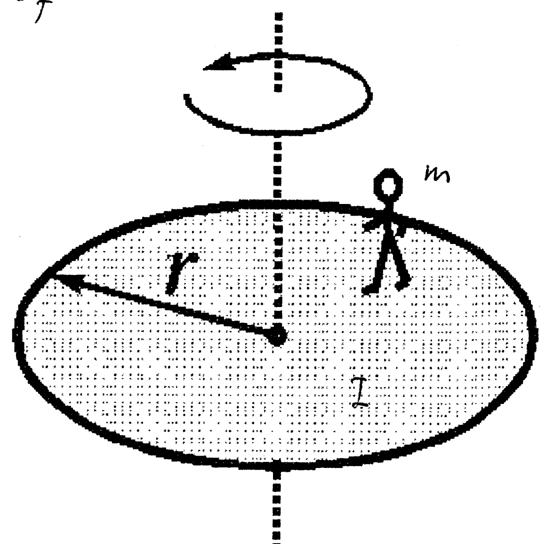
$$N_1 = \frac{mg\cos\theta}{2\sin\theta}$$

$$f = N_1 = \frac{6.0 \times 9.8 \times \cos 60^\circ}{2 \sin 60^\circ} = 17.0\ N$$

Answer 7: 17.0 N

8. A horizontal platform with a radius of 5.00 m rotates about a frictionless vertical axle. The moment of inertia of the platform about the axle is 1000 kg·m^2. A student (m=80.0 kg) walks slowly from the rim of the platform toward the center and stops when he is at the centre. The initial angular velocity ω of the system is 4.00 rad/s when the student is at the rim. (You may treat the person as a point mass)

(a) Find the angular speed when the student is at the center.
(b) Find the work done by the student.



(a). Conservation of angular momentum : $L_i = L_f$
(Because external torque $=0$).

$$(I + mr^2)\omega_i = I\omega_f .$$

$$\omega_f = \frac{I + mr^2}{I}\omega_i$$

$$= \frac{1000 + 80 \times 5^2}{1000}\omega_i$$

$$= 3\omega_i = 3 \times 4 = 12.0 \text{ rad/s}$$

(b). $W = KE_f - KE_i$.

$$= \frac{1}{2} I \omega_f^2 - \frac{1}{2}(I + mr^2)\omega_i^2$$

$$= \frac{1}{2}(1000)(12)^2 - \frac{1}{2}(1000 + 80 \times 5^2) 4^2$$

$$= 72000 - 24000$$

$$= 48000 \text{ J}$$

Answer 8(a): 12.0 rad/s

Answer 8(b): 48000 J .

PHYS 101 Midterm Examination #2 (version B)

March 11, 2011

Time: 50 minutes

Last Name : Key

First Name : Michael

Student No. : ____________________

Computing ID : ____________________

Tutorial Section : ____________________

	score	*Maximum*
Multiple Choice #1-5		**5**
Written # 6		**5**
Written # 7		**5**
Written # 8		**5**
Total		**20**

Part I (Multiple choice questions. 1 mark each.)

A

1. Two points, A and B, are on a disk that rotates about an axis. Point A is three times as far from the axis as point B. If the speed of point A is v, what is the speed of point B?
   - (A) v/3
   - B) v
   - C) 3v
   - D) 9v
   - E) $\sqrt{3}$ v

$v = r\omega \propto r$

E

2. A hoop, a disk, and a solid sphere are released at the same time at the top of an inclined plane. They all roll without slipping. In what order do they reach the bottom?
   - A) disk, hoop, sphere
   - B) disk, sphere, hoop
   - C) sphere, hoop, disk
   - D) hoop, disk, sphere
   - (E) sphere, disk, hoop

C

3. A uniform steel wire was cut into two pieces. The first piece is 2.0 meters long and the second piece is 20meters long. The Young's modulus of the first piece is is Y. What is the Young's modulus of the second piece?
   - A) 0.01Y
   - B) 0.1Y
   - (C) Y
   - D) 10Y
   - E) 100Y

A

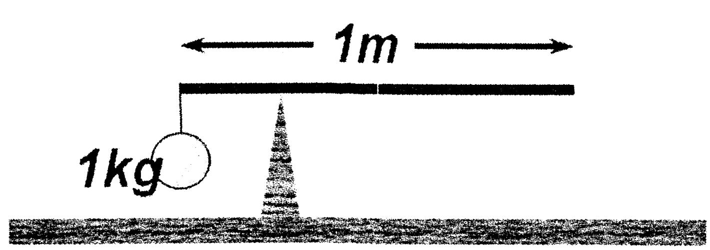
4. Two disks are cut from the same metal sheet. Disk A has a radius R and a moment of inertia I, while disk B has a radius 2R. What is the moment of inertia of disk B?
   - (A) 16I
   - B) 8I
   - C) 4I
   - D) 2I
   - E) I

$I = \frac{1}{2}MR^2$ $M = \pi R^2 \cdot h\rho \propto R^2$

$I \propto R^4$ $2^4 = 16$

C

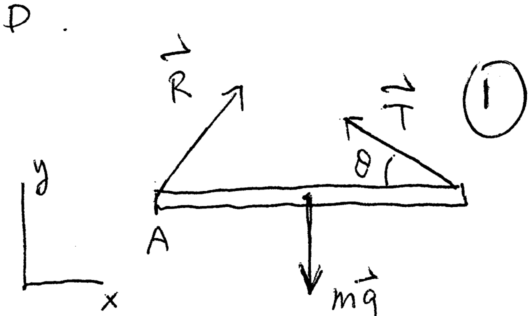
5. A 1-kg ball is hung at the end of a rod 1-m long. If the system balances at a point on the rod 0.25 m from the end holding the mass, what is the mass of the rod?
   - A) 0.25 kg
   - B) 0.50 kg
   - (C) 1 kg
   - D) 2 kg
   - E) 4 kg

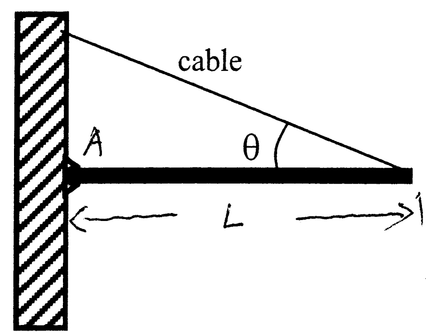


Part II (Full solution questions, 5 marks each. **SHOW ALL WORK FOR FULL MARKS!**)

6. A uniform beam, 2.00 m long with mass m = 4.00 kg, is mounted by a small hinge on a wall (the frictional torque at the small hinge is negligible). The beam is held in a horizontal position by a cable that makes an angle θ = 25.0° with the beam.
(a) Find the magnitude of the force exerted by the hinge on the beam (show your free body diagram of the beam).
(b) If the cable breaks, the beam will start to rotate about the hinge. Find the angular acceleration of the beam.

FBD.





(1) (a). $\sum \vec{F} = 0$: $R_x - T\cos\theta = 0$ ①

$R_y + T\sin\theta - mg = 0$ ②

(1) $\sum \tau = 0$ (About point A).

$LT\sin\theta - mg\frac{L}{2} = 0$ ③

$T = \frac{mg}{2\sin\theta}$

①: $R_x = T\cos\theta = \frac{mg\cos\theta}{2\sin\theta}$

②: $R_y = mg - T\sin\theta$

$= mg - \frac{mg}{2\sin\theta}\cdot\sin\theta$

(1) $= \frac{mg}{2}$.

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{\left(\frac{mg\cos\theta}{2\sin\theta}\right)^2 + \left(\frac{mg}{2}\right)^2}$

$= \frac{mg}{2}\sqrt{\frac{\cos^2\theta}{\sin^2\theta} + 1} = \frac{mg}{2}\sqrt{\frac{\cos^2\theta + \sin^2\theta}{\sin^2\theta}}$

$= \frac{mg}{2\sin\theta} = \frac{4\times 9.8}{2\cdot\sin 25°} = 46.4\ N$

(b) $\tau = -mg\cdot\frac{L}{2}$, $I = \frac{1}{3}mL^2$

(1) $\alpha = \frac{\tau}{I} = -\frac{mgL/2}{\frac{1}{3}mL^2} = -\frac{3g}{2L}$

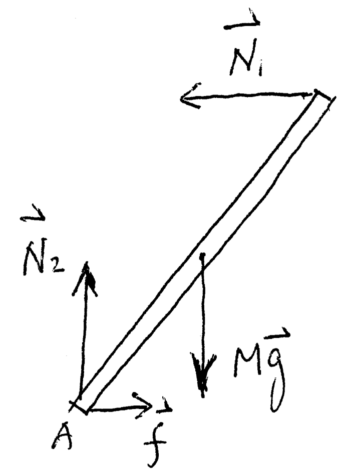
$= \frac{-3\times 9.8}{2\times 2} = -7.35\ rad/s^2$

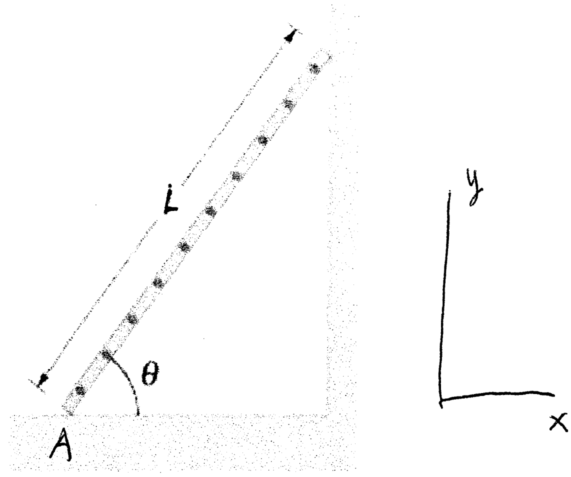
Answer 6(a): 46.4 N

Answer 6(b): $-7.35\ rad/s^2$.

7. A uniform ladder of mass M=5.0kg and length L=4.0m leans against a frictionless wall at an angle θ=60° . Determine the frictional force between the ladder and the ground. Include a free body diagram of the ladder.

FBD





$\Sigma \vec{F} = 0$:

$f - N_1 = 0$

$N_2 - Mg = 0$

$\Sigma \tau = 0$ (about point A)

$N_1 L \sin\theta - Mg \frac{L}{2} \cos\theta = 0$, $N_1 L \sin\theta = Mg \frac{L}{2} \cos\theta$

$N_1 = \dfrac{Mg \cos\theta}{2 \sin\theta}$

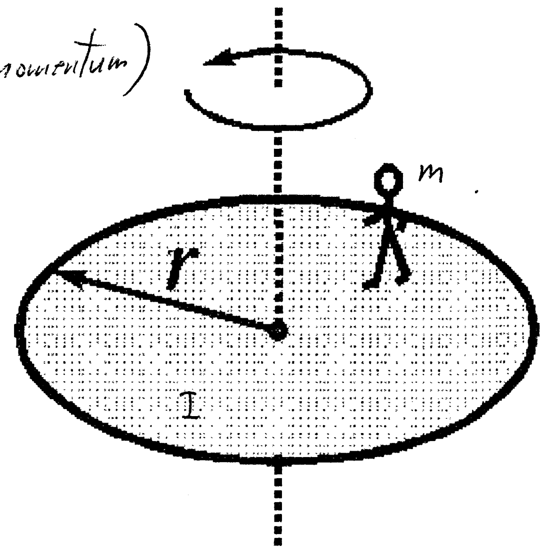
$f = N_1 = \dfrac{Mg \cos\theta}{2 \sin\theta} = \dfrac{5 \times 9.8 \times \cos 60^\circ}{2 \times \sin 60^\circ} = 14.1\ N$

Answer 7: 14.1 N

8. A horizontal platform with a radius of 5.00 m rotates about a frictionless vertical axle. The moment of inertia of the platform about the axle is 1000 kg·m^2. A student (m=80.0 kg) walks slowly from the rim of the platform toward the center and stops when he is at the centre. The initial angular velocity ω of the system is 3.00 rad/s when the student is at the rim. (You may treat the person as a point mass)

(a) Find the angular speed when the student is at the center.
(b) Find the work done by the student.

(2) (a). External torque = 0.
$L_i = L_f$ (conservation of angular momentum)



$(I + mr^2)\,\omega_i = I \cdot \omega_f$ — 0.5

(1) $\omega_f = \dfrac{I + mr^2}{I}\,\omega_i$

$= \dfrac{1000 + 80 \times 5^2}{1000}\,\omega_i$ 0.5

$= 3\,\omega_i$

$= 3 \times 3 = 9$ rad/s.

(b) $W = KE_f - KE_i = \frac{1}{2} I \omega_f^2 - \frac{1}{2}(I + mr^2)\,\omega_i^2$ (1)

$= \frac{1}{2}(1000) \cdot 9^2 - \frac{1}{2}(1000 + 80 \times 5^2)\, 3^2$

(1) $= 27000$ J

Answer 8(a): 9 rad/s

Answer 8(b): 27,000 J