

# Solutions

Wednesday, January 14, 2026 2:30 PM



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Name: \_\_\_\_\_

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## Physics 202

### Midterm 1

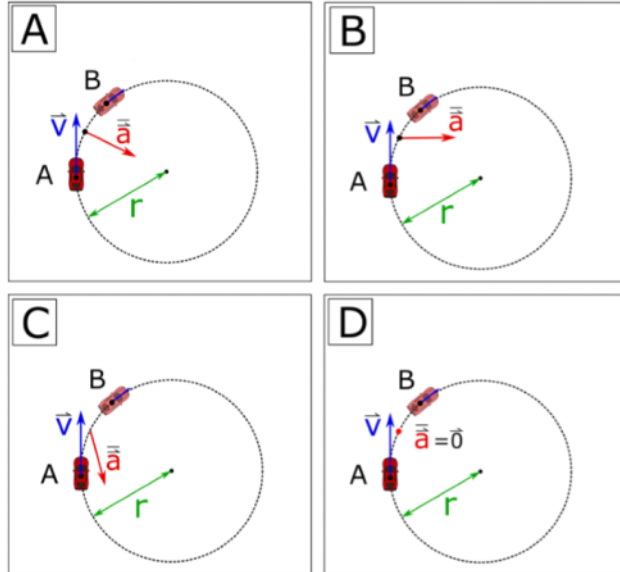
1/28/2026

Collaboration is not allowed. Allowed on your desk are: ten 8.5 x 11 inch doubled-sided sheets of notes that are bound together, non-communicating graphing scientific calculator, a page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam.

For questions 1 through 4 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are 6 correct answers in this section and only the first 6 filled in answers will be graded. There is no partial credit.

1. Which one of following diagrams best represents a car that is slowing down between points A and B?

- (a)  
 (b)  
 (c)  
 (d)



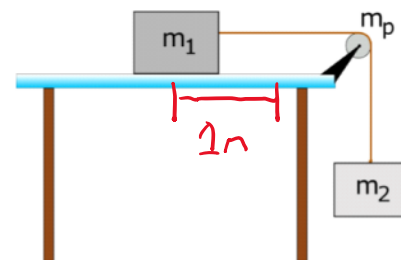
2. A person is sitting in a chair that rotates without friction at an angular velocity  $\omega$ . Their arms are extended and they are holding heavy bags of groceries. They get tired and bring the groceries closer to their core. In doing this, they decrease their moment of inertia to two thirds of the original value. What **one** will be their final angular velocity after bringing their arms in?

- (a)  $0.50 \omega$   
 (b)  $1.00 \omega$   
 (c)  $1.50 \omega$   
 (d)  $0.67 \omega$   
 (e)  $1.25 \omega$   
 (f)  $1.67 \omega$   
 (g)  $0.75 \omega$   
 (h)  $1.34 \omega$   
 (i)  $2.00 \omega$

$L = I \omega$   
 $\downarrow \frac{2}{3} \quad \uparrow \frac{3}{2}$

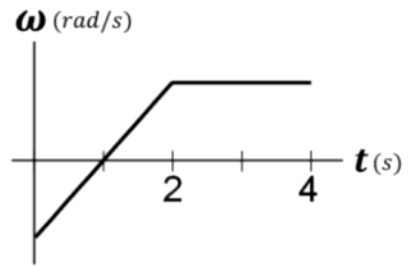
3. Consider  $m_1$  in the figure slides a meter to the right. This causes the disk of the pulley to rotate through an angle  $\Delta\theta$ . If the radius of the pulley increases by a factor of 4, and  $m_1$  slides again through one meter, what **one** angle will the pulley subtend (go through)?

- (a)  $0.25 \Delta\theta$   
 (b)  $1.00 \Delta\theta$   
 (c)  $2.50 \Delta\theta$   
 (d)  $0.50 \Delta\theta$   
 (e)  $1.50 \Delta\theta$   
 (f)  $4.00 \Delta\theta$   
 (g)  $0.75 \Delta\theta$   
 (h)  $2.00 \Delta\theta$   
 (i)  $16.0 \Delta\theta$



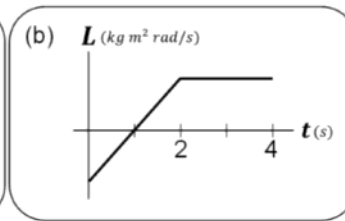
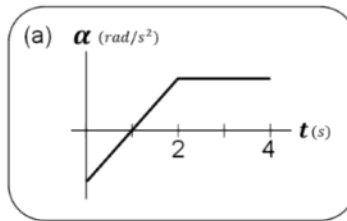
$\theta = \frac{s}{r} \Rightarrow 4$

4. A dapper gentleman bug goes for a ride on a classic Elton John record. The gentleman bug sits at a constant radius during the motion, which is described by the angular velocity shown here. Which of the following graphs could also describe the motion of the gentleman bug?



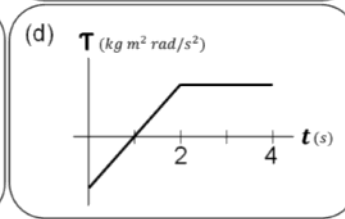
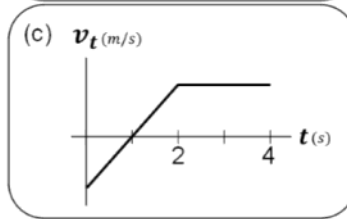
- (a)     (b)     (c)     (d)     (e)     (f)

$$\alpha = \frac{\Delta\omega}{\Delta t}$$

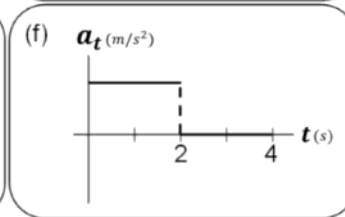
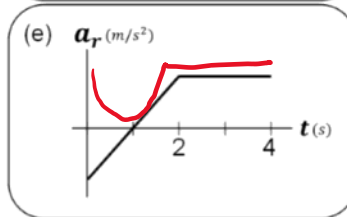


$$L = I\omega$$

$$v_t = \omega r$$



$$\tau = I\alpha$$

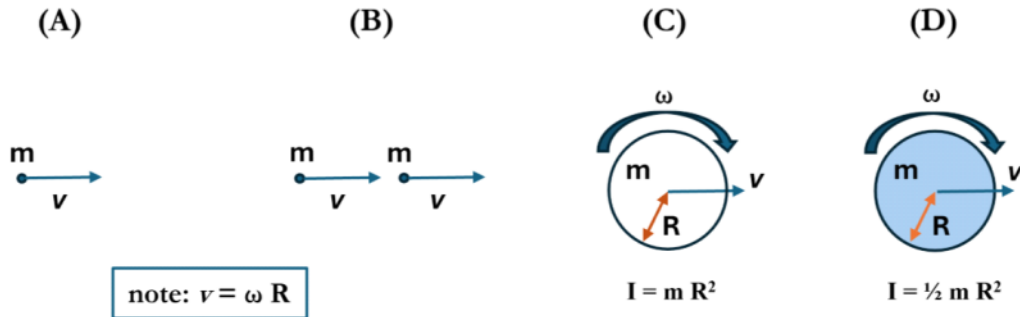


$$a_r = \omega^2 r$$

$$a_t = \alpha r = \frac{\Delta\omega}{\Delta t} r$$

↑ slope                      ↑ const

5. (6 points) Consider the following: system (A) consists of a point particle, system (B) two point particles, system (C) a hollow cylinder, and system (D) a solid cylinder. Both the cylinders have the same radius, and all the objects have the same mass and translational speed. Other information is provided in the diagram.



- (a) For each system identify if it has translational and/or rotational kinetic energy.

A                      B                      C                      D  
 $KE_t$                        $KE_t$                        $KE_t + KE_r$                        $KE_t + KE_r$

- (b) Calculate the **total** kinetic energy for each system in terms of the variables  $m$  and  $v$  only (numbers like 2 or  $\frac{1}{2}$  are also fine).

A

$$KE_{tot} = \frac{1}{2} m v^2$$

B

$$KE_{tot} = \frac{1}{2} m v^2 + \frac{1}{2} m v^2$$

$$= m v^2$$

C

$$KE_{tot} = \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2$$

$$= \frac{1}{2} m v^2 + \frac{1}{2} (m R^2) \left(\frac{v}{R}\right)^2$$

$$= m v^2$$

D

$$KE_{tot} = \frac{1}{2} m v^2 + \frac{1}{2} \left(\frac{1}{2} m R^2\right) \left(\frac{v}{R}\right)^2$$

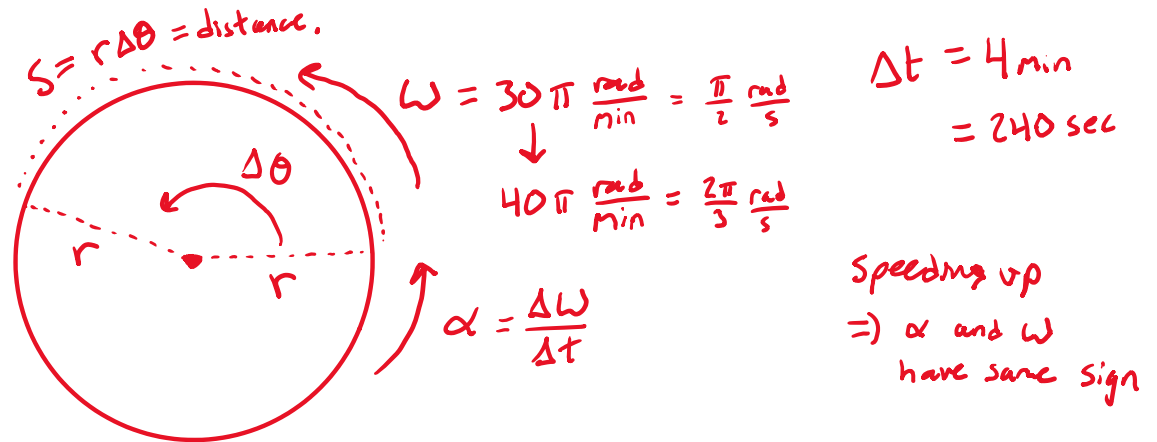
$$= \frac{3}{4} m v^2$$

- (c) Rank the systems based on their total kinetic energy.

$$KE_B = KE_C > KE_D > KE_A$$

(a) - 2 pts  
 Presence of translational and rotational KE  
 (b) - 3 pts  
 Representation of kinetic energies  
 Manipulation and addition  
 (c) - 1 pt  
 Correctness of order

6. (8 points) A large 75-m-radius wind turbine is initially rotating at  $30\pi$  radians per minute. As the wind picks up over the span of 4 minutes, it speeds up uniformly to  $40\pi$  radians per minute.
- What is the magnitude of the angular acceleration of the turbine during this time?
  - What is the total distance travelled, in meters, of a point on the tip of the turbine during this time?
  - If the moment of inertia of a wind turbine is  $3.3 \times 10^8 \text{ kg m}^2$ , what is the magnitude of net torque applied by the wind to the wind turbine during this time?



$$a) \quad \alpha = \frac{\Delta\omega}{\Delta t} = \frac{10\pi \frac{\text{rad}}{\text{min}} \left(\frac{1}{60} \frac{\text{min}}{\text{s}}\right)}{(4 \text{ min}) \left(\frac{60 \text{ s}}{1 \text{ min}}\right)}$$

$$\alpha = 2.18 \times 10^{-3} \frac{\text{rad}}{\text{s}^2}$$

$$b) \quad \Delta\theta = \omega_i \Delta t + \frac{1}{2} \alpha \Delta t^2$$

$$\Delta\theta = 440 \text{ rad}$$

$$s = r\Delta\theta$$

$$= 33,000 \text{ m}$$

$$c) \quad \tau = I\alpha$$

$$\tau = (3.3 \times 10^8 \text{ kg m}^2) (2.18 \times 10^{-3} \frac{\text{rad}}{\text{s}^2})$$

$$\tau = 719,000 \text{ N}\cdot\text{m}$$

7. (5 points) Figure 1 below shows the forces acting on a person's spine while lifting a box. The person is not lifting with proper technique and risks injuring their back. Proper technique would be a more upright posture that keeps their spine more vertical. Figure 2 shows the difference between proper and improper lifting posture.

Figure 1

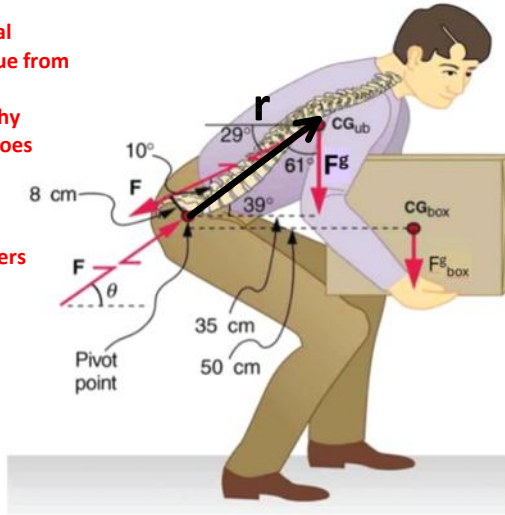
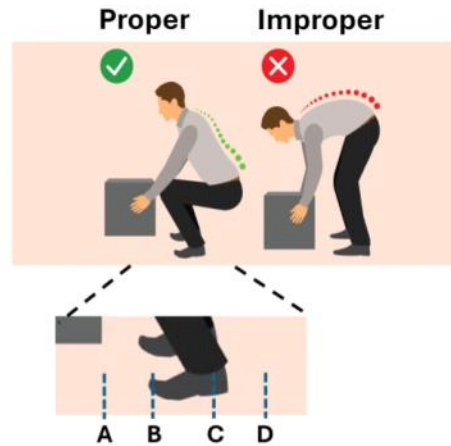


Figure 2



Rubric:

Part (a) - 3 points total

1 pt - answer: torque from weight goes down

2 pts - reasoning why torque from weight goes down

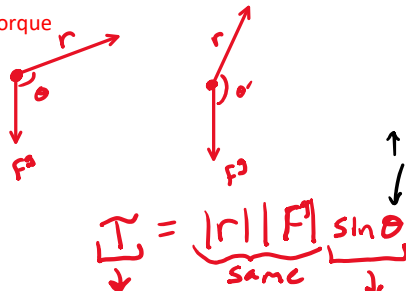
Part (b) - 2 points

1 pt - Correct answers

1 pt - reasoning

- (a) If the person in figure 1 was to lift with a more proper posture, by making their spine more vertical, how would that change the torque from their weight ( $F_g$ ) about the pivot point at the bottom of the spine in the diagram? Would this increase, decrease, or keep the net torque on their spine the same? Explain using the physics concepts taught in this class (i.e. don't use physiological explanations from anatomy or descriptions from trainers).

Vector Operation for Torque



$\Rightarrow$  less torque from  $F_g$  on spine, but net torque stays the same b/c back muscle torque can now be lessened

- (b) Consider the proper lifting position in figure 2. What point(s) (A, B, C, D) could the center of mass of person + box system be directly vertically above? Explain.

C.M. must be between B & C (inclusive)  
if C.M. is outside points of contact, the system will tip over!

$$\sum \tau = I \alpha$$

unchanged