2-2C-1

PHYS 101 Midterm examination #2 (vers. 2C)

15 Nov., 2002 — Name: Key

Time: 50 minutes — Student No. ____________

For questions 2 and 3, please show complete solutions and explain your reasoning, stating any principles that you have used.

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1 (10 marks). For each of the following five questions, please circle one answer only.

(a) (i) A solid cylinder is rolling without slipping. What fraction of its kinetic energy is rotational?

- (a.) 1/3
- b. 2/3
- c. 1/2
- d. 3/4
- e. 2/7

$K_T = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ $K_R = \frac{1}{2}I\omega^2$

$I = \frac{1}{2}mr^2$, $\omega = \frac{v}{r}$. $K_R = \frac{1}{2}\cdot\frac{1}{2}mr^2\omega^2 = \frac{1}{4}mv^2$

$\therefore K_T = \frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{3}{4}mv^2$. $K_R/K_T = \frac{1}{4}/\frac{3}{4} = 1/3$

(e) (ii) A 5.0-m radius playground merry-go-round with a moment of inertia of 2000 kg·m^2 is rotating freely with an angular speed of 1.0 rad/s. Two people, each having a mass of 40 kg are standing right outside the edge of the merry-go-round and step on it with negligible speed. What is the angular speed of the merry-go-round right after the two people have stepped on?

- a. 0.40 rad/s
- b. 0.60 rad/s
- c. 0.80 rad/s
- d. 0.67 rad/s
- (e.) 0.50 rad/s

$L_f = L_i$. $I_f = I_i + 2mr^2 = 2000 + (2)(40)(5)^2$

$I_f \cdot \omega_f = I_i \omega_i$. $= 4000 \text{ kg}\cdot\text{m}^2$.

$\omega_f = \frac{I_i}{I_f}\cdot\omega_i$. $\therefore \omega_f = \frac{2000}{4000}\cdot\omega_i = \frac{1}{2}\omega_i = 0.50 \text{ rad/s}$

(d) (iii) In simple harmonic motion, the acceleration is proportional to

- a. the velocity
- b. the frequency
- c. the amplitude
- (d.) the displacement
- e. the period

$a = -\omega^2 x$

(c) (iv) The vertical displacement of a string is given by y(x,t) = 0.006 cos(3.25x - 7.22 t), where all quantities are measured in SI units. What is the speed of the wave?

- a. 0.450 m/s
- b. 1.41 m/s
- (c.) 2.22 m/s
- d. 0.870 m/s
- e. 1.93 m/s

$y(x,t) = A\cdot\cos(kx - \omega t) = A\cos[k(x - vt)]$.

$v = \frac{\omega}{k} = \frac{7.22}{3.25} = 2.22 \text{ m/s}$.

(b) (v) By what amount does the intensity level increase when you triple the intensity of a source of sound?

- a. 9.5 dB
- (b.) 4.8 dB
- c. 6.0 dB
- d. 3.0 dB
- e. 4.0 dB

$\beta = \log_{10}\left(\frac{I}{I_0}\right)$

$\beta_1 = \log_{10}\left(\frac{I_1}{I_0}\right)$

$\beta_2 = \log_{10}\left(\frac{I_2}{I_0}\right)$

$\Delta\beta = \beta_2 - \beta_1 = 10\log_{10}\left(\frac{I_2}{I_1}\right)$

Now $I_2 = 3I_1$.

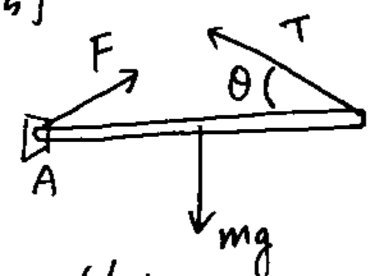
$\Delta\beta = 10\log_{10}(3) = 4.8 \text{ dB}$

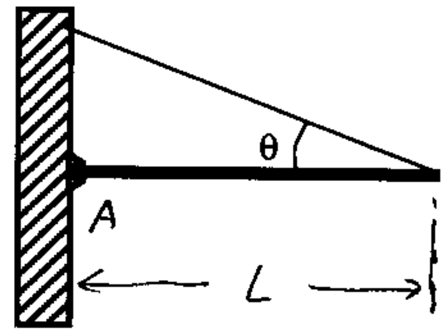
2 (6 marks). A uniform steel rod, with a mass of 20.0 kg and 3.00 m long, is supported by a loose bolt attached to the wall at one end and by a wire at the other end. The wire makes an angle of θ=25° with the horizontal as shown in the figure below.

(a). What is the magnitude of the force exerted by the bolt on the rod?

(b). If the wire breaks, what is the angular acceleration of the rod?

[solution]





1/6

static equilibrium:

$\sum \vec{F}_i = 0$: $F_x - T\cdot\cos\theta = 0$ ①

$F_y + T\sin\theta - mg = 0$ ②

1/6

$\sum \vec{\tau} = 0$ (About point A) : $T\cdot L\cdot\sin\theta - mg\frac{L}{2} = 0$ ③

Solve ③ for T : $T = \dfrac{mg}{2\sin\theta} = \dfrac{(20)(9.8)}{2\sin 25^\circ} = 232\ N$

1/6

Solve ① for F_x : $F_x = T\cdot\cos\theta = 232\cdot\cos 25^\circ = 210\ N$

Solve ② ③ for F_y : $F_y = \dfrac{mg}{2} = 98\ N$.

(a) : $F = \sqrt{F_x^2 + F_y^2} = \sqrt{(210)^2 + (98)^2} = 232\ N$

2/6

(b). if the wire breaks, $T = 0$. $\quad \tau = -mgL/2$;

$I = \frac{1}{3}mL^2$. (Moment of inertia of the rod about A)

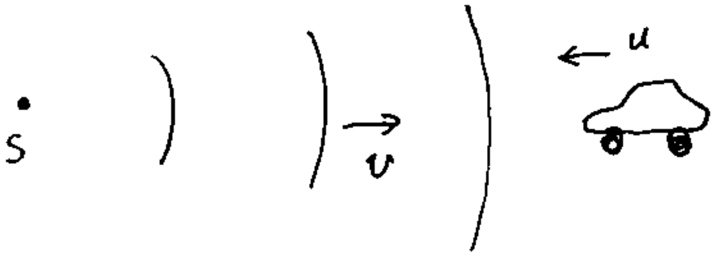
angular acceleration : $\alpha = \dfrac{\tau}{I}$.

$\alpha = \dfrac{-\frac{1}{2}mgL}{\frac{1}{3}mL^2} = -\dfrac{3g}{2L} = -\dfrac{3(9.8)}{2(3)} = 4.9\ rad/s^2$.

clockwise.

3(4 marks). A policeman in a stationary car measures the speed of approaching cars by means of an ultrasonic device that emits a sound with a frequency of 39.6 kHz. A car is approaching him at a speed of 35.0 m/s. The wave is reflected by the car and interferes with the emitted sound producing beats. What is the frequency of the beats? The speed of sound in air is 343 m/s.

[Solution]:



(1/4) When the wave is on its way to the car, the car is a moving observer:

$$f' = f(1 + u/v) \quad \text{[approaching]}$$

(1/4) When the wave is reflected and going towards the policeman, the car is a moving source: [approaching]

$$f'' = f'/(1 - u/v) = f\,\frac{1 + u/v}{1 - u/v}$$

(2/4) The frequency of the beat:

$$f_B = f'' - f = f\left[\frac{1 + u/v}{1 - u/v} - 1\right]$$

$$= f\,\frac{2u/v}{1 - u/v} = f\,\frac{2u}{v - u}$$

$$= 3.96 \times 10^4\,\frac{2\,(35)}{343 - 35}$$

$$= 9.0 \times 10^3\ Hz.$$

$$= 9\ kHz.$$