2-2D-1

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

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.

(i) A hoop 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

(C)

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

$= \frac{1}{2}mr^2\omega^2 + \frac{1}{2}I\omega^2$

$= \frac{1}{2}I\omega^2(1+1) = (2)\cdot\frac{1}{2}I\omega^2$.

(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 60 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

(a)

$L_f = L_i$. $I_f = I_i + mr^2 + mr^2$.

$\omega_f I_f = \omega_i I_i$. $= 2000 + 2(60)(5)^2 = 5000$ kg·m^2

$\omega_f = \frac{I_i}{I_f}\omega_i$. $\omega_f = \frac{2000}{5000}\cdot 1 = 0.4$ rad/s

(iii) In simple harmonic motion, the speed is the greatest when

a. the magnitude of the acceleration is a maximum
b. the displacement is a maximum
c. the magnitude of the acceleration is a minimum
d. the potential energy is a maximum
e. the kinetic energy is a minimum

(C)

V_{max} occurs at $x = 0$. (equilibrium position)

$a = -\omega^2 x$

∴ when $x = 0$, $a = 0$. $|a| = \min$.

(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

(C)

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

where $v = \frac{\omega}{k}$.

$v = \frac{7.22}{3.25} = 2.22$ m/s

(v) By what amount does the intensity level increase when you double 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

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

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

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

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

$I_2 = I_1$.

∴ $\Delta\beta = 10\log_{10}(2)$

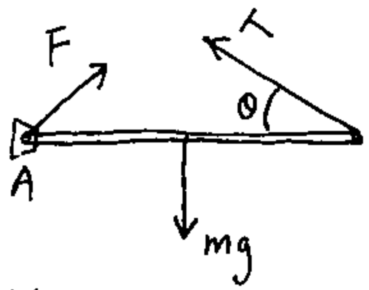
$= 3.0$ dB

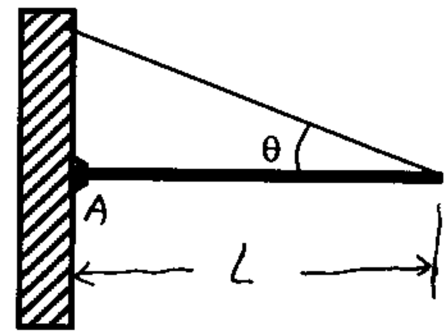
2(6marks). A uniform steel rod, with a mass of 20.0 kg and 3.00 m long, is supported by a loose bolt attached to the wall at one end and by a wire at the other end. The wire makes an angle of θ=35° with the horizontal as shown in the figure.

(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 :

$\Sigma \vec{F}_i = 0$. $\quad F_x - T\cdot\cos\theta = 0 \quad$ ①

$F_y + T\sin\theta - mg = 0 \quad$ ②

1/6

$\Sigma \vec{\tau}_i = 0$ (about point A) : $\quad TL\sin\theta - mg\frac{L}{2} = 0$

$T\cdot\sin\theta = mg/2$. $\quad$ ③

from ③: $\quad T = \dfrac{mg}{2\sin\theta} = \dfrac{(20)(9.8)}{2\sin 35^\circ} = 171\ N$

1/6

from ①: $\quad F_x = T\cdot\cos\theta = (171)(\cos 35^\circ) = 140\ N$.

from ② and ③: $\quad F_y = mg/2 = \dfrac{(20)(9.8)}{2} = 98\ N$

(a): $\quad F = \sqrt{F_x^2 + F_y^2} = \sqrt{140^2 + 98^2} = 171\ N$.

2/6

(b). when the wire breaks, $T = 0$.

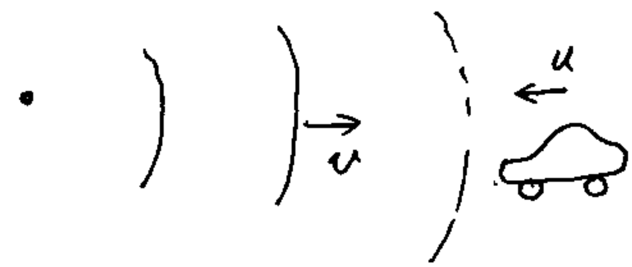
$\tau = -mg\frac{L}{2}$ (clockwise).

angular acceleration of the rod about A : $\alpha = \dfrac{\tau}{I}$.

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

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 25.0 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 car receives the wave, the car is a moving observer:

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

1/4

When the wave is reflected by the car, the car is a moving source approach the policement:

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

2/4

The frequency of the beat:

$$f_B = |f'' - f| = f'' - f = f\left[\frac{1 + u/v}{1 - u/v} - 1\right] = f \frac{2u/v}{1 - u/v}$$

$$f_B = \frac{2uf}{v - u}$$

$$= \frac{2(25)\,39600}{343 - 25}$$

$$= 6.23 \times 10^3 \text{ Hz}.$$

$$= 6.23 \text{ KHz}.$$