103ex2

Physics 103 Exam 2 October 31, 2002

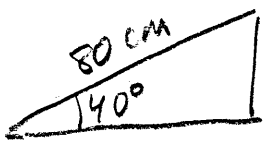
Name DEL ID #__________

Section #__________ TA Name__________

Fill in your name, student ID # (not your social security #), and section # (under ABC of special codes) on the Scantron sheet. Fill in the letters given for the first 5 questions on the Scantron sheet. These letters determine which version of the test you took, and it is very important to get this right. Make sure your exam has questions 6—25.

1. B
2. D
3. E
4. C
5. A
6. How much work is done by gravity when a 5-kg mass is pushed 80 cm along a plane inclined upward at an angle of 40° from the horizontal?

   a. –39.2 J
   b. –25.2 J
   c. 25.2 J
   d. 39.2 J
   e. 76.2 J



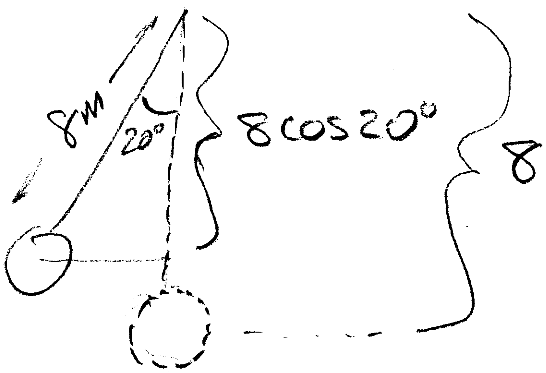
80 CM × SIN 40 = 0.80 M × SIN 40° = h

$mgh = 5 \times 9.8 \times 0.8 \sin 40 = 25.2$

GRAVITY IS OPPOSITE THE MOTION SO − SIGN

7. A bowling-ball pendulum of length 8 m is released from rest at an angle of 20° from the vertical. What is the maximum speed the bowling ball obtains?

   a. 4.35 m/s
   b. 4.49 m/s
   c. 9.46 m/s
   d. 3.08 m/s
   e. 7.32 m/s



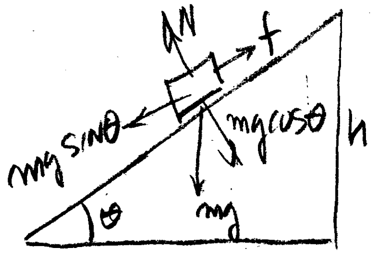
BALL IS $8 - 8\cos 20°$ LOWER; $KE_i = PE_f = 0$

SO $PE_i = KE_f \Rightarrow \frac{1}{2} mv^2 = mgh$

$v = \sqrt{2gh} = \sqrt{2g(8 - 8\cos 20°)} = 3.08$ m/s

$h = 50\text{ cm} = 0.50\text{ m}$

8. A block is released from rest at a vertical height of 50 cm on a plane inclined at an angle of 25° from the horizontal and slides down the plane, reaching a speed of 2 m/s at the bottom. What is the coefficient of kinetic friction between the block and the plane?



NO MOTION IN DIRECTION OF N SO $N = mg\cos\theta$.
$f = \mu N = \mu mg\cos\theta$
IF THE LENGTH OF THE INCLINE IS L

a. 0.250
b. 0.276
c. 0.536
d. 0.657
e. 0.394

9. A spring-loaded gun with a spring initially compressed by 5 cm propels a 100-g object vertically upward to maximum height of 8 m. What is the spring constant of the spring?

$\frac{1}{2}kx^2 = mgh$ (SPRING PE IS CONVERTED TO GRAVITY PE AT MAX. h

$k = \frac{2mgh}{x^2} = \frac{2(0.100\text{ kg})9.8(8\text{ m})}{(.05\text{ m})^2}$

$k = 6270$

a. 627 N/m
b. 3136 N/m
c. 6270 N/m
d. 1568 N/m
e. 314 N/m

10. What minimum power does an 80-kg student produce when climbing a flight of stairs to a height of 10 m in a time of 15 s?

$P = \frac{\text{WORK}}{\text{TIME}} = \frac{\text{GAIN IN PE}}{\text{TIME}} = \frac{mgh}{t} = \frac{80\times 9.8\times 10}{15}$

$P = 523\text{ W}$

a. 1176 W
b. 480 W
c. 523 W
d. 588 W
e. 960 W

11. When a ball bounces elastically off the floor, which one of the following is false?

a. The Earth recoils downward. YES
b. The force of gravity is momentarily absent. NO !
c. The impulse on the Earth and ball are equal and opposite. YES
d. The momentum of the Earth plus ball is constant. YES
e. The ball momentarily stores potential energy in compression. YES

THEN $h/L = \sin\theta$ SO $L = h/\sin\theta$

WORK BY GRAVITY IS mgh; WORK BY FRICTION IS $-fL$

KINETIC ENERGY IS SUM OF THESE ; $\frac{1}{2}mv^2 = mgh - fL$

OR $\frac{1}{2}mv^2 = mgh - \mu mg\cos\theta\left(\frac{h}{\sin\theta}\right)$

$\frac{v^2}{2gh} = 1 - \mu\frac{\cos\theta}{\sin\theta}$ SO $\mu = \frac{\sin\theta}{\cos\theta}\left(1 - \frac{v^2}{2gh}\right) = \tan\theta\left(1 - \frac{v^2}{2gh}\right)$

PLUG IN $\theta = 25°$, $h = 0.50\text{ m}$, $v = 2\text{ m/s}$.

12. A 1000-kg automobile traveling at 30 MPH collides with a 2000-kg truck originally at rest and locks bumpers with the truck. What is the speed of the automobile after the collision?

a. 15 MPH
b. 10 MPH
c. 7.5 MPH
d. 0 MPH
e. 17.3 MPH

$M_1 V_0 = (M_1 + M_2) V_F$

$V_F = \frac{M_1}{M_1 + M_2} V_0 = \frac{1000\,kg}{3000\,kg} \times 30\,MPH$

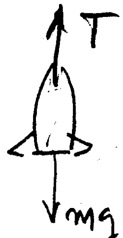
$V_F = 10\ MPH$

13. In what kind of collision is kinetic energy conserved?

a. Inelastic collision
b. Perfectly inelastic collision
c. Elastic collision
d. Collision between equal masses
e. All collisions

14. A rocket is launched vertically upward from the surface of the Earth with an upward acceleration of 2 m/s^2 by ejecting exhaust at a velocity of 1000 m/s. What fraction of the rocket's mass is ejected per second?

a. 0.002
b. 0.0098
c. 0.0118
d. 0.00118
e. 0.02



T = THRUST FORCE $= V_e \frac{\Delta m}{\Delta t}$

$T - mg = ma$

$T/m = a + g = V_e \frac{(\Delta m/m)}{\Delta t}$

$\Delta m/m = (a+g)\Delta t / V_e = \frac{(2+9.8)(1s)}{1000}$

15. If the rocket in the previous problem is in deep space, by how much can it change its velocity if it consumes 50% of its mass?

a. 301 m/s
b. 2000 m/s
c. 1000 m/s
d. 693 m/s
e. 500 m/s

$v_f - v_i = v_e \ln\left(\frac{M_i}{M_f}\right)$

$M_f = (50\%) M_i = 0.5 M_i$ so $\frac{M_i}{M_f} = 2$

$v_f - v_i = 1000 \ln 2 = 693\ m/s$

16. A wheel rotating at a rate of 80 revolutions per minute decelerates at a rate of 5 rad/s^2. How many seconds are required for it to come to rest?

a. 16 s
b. 3.36 s
c. 1.68 s
d. 1.83 s
e. 1.33 s

$80\ rev/min \times 2\pi\ rad/rev \times 1\ min/60\ sec =$

$= 8.377\ rad/s$

$\omega_f = \omega_0 + \alpha t$

$0 = 8.377 - 5t \quad t = 8.377/5$

17. A car traveling along a level road rounds a curve with a radius of 50 m and hits a patch of ice where the coefficient of friction between the wheels and the road is only 0.1. Above what speed will the car slide off the road?

a. 49 m/s
b. 7 m/s
c. 70 m/s
d. 22.1 m/s
e. 49.5 m/s

$$\frac{\cancel{m} v^2}{r} = f = \mu_s N = \mu_s \cancel{m} g$$

$$v^2 = \mu_s r g$$

$$v = \sqrt{\mu_s r g} = \sqrt{.1 \times 50 \times 9.8} = 7 \text{ m/s}$$

18. A mass on the end of 1.5-m string moves in a circular orbit making 2 revolutions per second. What is the magnitude of the acceleration of the mass, ignoring gravity?

a. 59.2 m/s^2
b. 37.7 m/s^2
c. 355 m/s^2
d. 237 m/s^2
e. 75.4 m/s^2

$$F_c = \frac{\cancel{m} v^2}{r} = \cancel{m} r \omega^2 = \cancel{m} a$$

$$\omega = 2 \frac{\cancel{\text{rev}}}{s} \times 2\pi \frac{\text{rad}}{\cancel{\text{rev}}} = 4\pi \text{ rad/s}$$

$$a = r\omega^2 = 1.5 (4\pi)^2 = 237$$

19. A planet with mass *m* orbits a star with a period *T* in a circular orbit of radius *R*. Which one of the following statements is true?

a. If *m* is increased, *R* must increase.
b. If *R* is increased, *T* must decrease.
c. If *R* is increased, *T* must increase.
d. If *m* is increased, *R* must decrease.
e. If *m* is increased, *T* must increase.

KEPLER'S LAW

$$T^2 \propto R^3$$

(m DOESN'T MATTER)

20. At what height above the surface of the Earth ($m_E = 5.98 \times 10^{24}$ kg, $R_E = 6.38 \times 10^6$ m) would a satellite orbit with a period of 2 hours?

a. 8.06×10^6 m
b. 6.49×10^6 m
c. 1.49×10^7 m
d. 8.49×10^6 m
e. 1.68×10^6 m

$$\frac{\cancel{m} v^2}{\cancel{r}} = \frac{G M_E \cancel{m}}{r^{\cancel{2}}} \qquad v = \frac{2\pi r}{T}$$

$$\left(\frac{2\pi r}{T}\right)^2 = \frac{G M_E}{r}$$

$$\frac{4\pi^2 r^2}{T^2} = \frac{G M_E}{r}$$

$$r^3 = \frac{G M_E T^2}{4\pi^2}$$

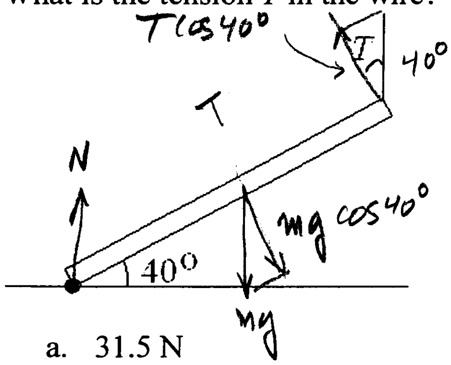
$$r = \left(\frac{G M_E T^2}{4\pi^2}\right)^{1/3}$$

$$r = \left[\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times (2 \times 3600)^2}{4\pi^2}\right]^{1/3}$$

$$r = 8.06 \times 10^6 \text{ m}$$

$$\text{HEIGHT} = r - R_E = 1.68 \times 10^6 \text{ m}$$

21. A uniform board with a mass of 10 kg rests with one end on the ground at an angle of 40° and the other end supported by a vertical wire from above as shown. What is the tension T in the wire?



$\sum F_y = 0 = N + T - mg$

$\sum \tau = 0 = T\cos 40^\circ \, \ell - mg\cos 40^\circ \frac{\ell}{2}$

$T - \frac{mg}{2} = 0 \quad T = \frac{mg}{2} = 49\,N$

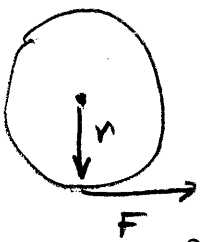
THE ANGLE DOESN'T MATTER!

(AND N IS ALSO 49 N)

a. 31.5 N
b. 37.5 N
c. 49 N
d. 41.1 N
e. 58.4 N

22. How much total torque does the engine have to deliver to the 60-cm-diameter wheels of a 1000-kg automobile to accelerate it by 3 m/s^2?

(ASSUME THE WHEELS ARE LIGHT)



a. 299 N-m
b. 1800 N-m
c. 9000 N-m
d. 2940 N-m
e. 900 N-m

TOTAL FORCE OF WHEELS ON ROAD = ma

F = 1000 x 3 m/s^2 = 3000 N. ON ALL WHEELS,

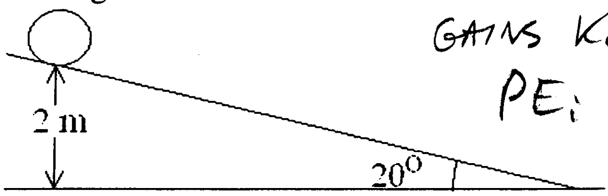
FORCE ACTS WITH A 30 CM = 0.3 M LEVER ARM

$\tau = Fr = 3000 \times .3 = 900$ TOTAL TORQUE.

23. Under which one of the following conditions is the angular momentum of an object never conserved?

a. When the angular velocity is changing
b. When there is a net external torque ← THIS ALWAYS CHANGES THE ANGULAR MOMENTUM.
c. When there is a net external force
d. When the object is accelerating
e. When work is done on the object

24. A uniform hoop rolls without slipping down a plane inclined at an angle of 20° from the horizontal from an initial height of 2 m as shown. With what speed is it moving when it reaches the bottom of the incline?



GAINS KE_f EQUAL TO INITIAL PE_i

$PE_i = mgh = KE_f$

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

$\omega = v/r$; $I = mr^2$ (HOOP)

SO $KE_f = \frac{1}{2}mv^2 + \frac{1}{2}(mr^2)\left(\frac{v}{r}\right)^2$

$KE_f = mv^2 = mgh$

$v^2 = gh \quad v = \sqrt{gh} = \sqrt{19.6}$

a. 6.26 m/s
b. 3.23 m/s
c. 3.13 m/s
d. 4.43 m/s
e. 5.42 m/s

25. A spinning ice skater doubles her angular velocity by raising her arms above her head. Which one of the following statements is true?

a. She does no work
b. Her angular momentum doubles
c. Her kinetic energy doubles
d. Her kinetic energy is reduced
e. Her angular momentum is reduced

ANGULAR MOMENTUM IS CONSERVED SO

$I_o\omega_o = I_f\omega_f$, IF ω_f IS DOUBLED,

$I_f = \frac{1}{2}I_o$. (THEN $I_f\omega_f = (\frac{1}{2}I_o)(2\omega_o) = I_o\omega_o$)

$KE_i = \frac{1}{2}I_o\omega_o^2$

$KE_f = \frac{1}{2}I_f\omega_f^2 = \frac{1}{2}(\frac{1}{2}I_o)(2\omega_o)^2$

$KE_f = \frac{1}{4}I_o \cdot 4\omega_o^2 = I_o\omega_o^2 = 2KE_i$